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R-356A
FINAL REPORT
MAGNET WIRE WELD STUDY
Jet Propulsion Laboratory

24 February 1965

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Jet Propulsion Laboratory
California Institute of Technology
4800 Oak Grove Drive
Pasadena, California

Ref: Statement of Work #950836

The Sippican Corporation
Marion, Mass.

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1. SUMMARY

This document represents the Final Report on Statement of Work #950836 with the Jet Propulsion Laboratory. The contract called for an investigation of the weldability of insulated magnet wire used with contact pins, and required the selection of the best combination of materials, development of a process (including weld schedules), and recommendations for welding equipment and automated production methods.

Based on several combinations of materials studied, it was decided that nickel was the only practical choice of a weldable, insulated magnet wire that would meet the strength and reliability requirements of the contract. At a meeting among C. B. Converse and P. SanClemente of The Sippican Corporation and L. Katzen of JPL, preliminary findings were discussed and agreement was reached to continue development of the process using nickel wire, although it was also agreed that copper wire, because of its non-magnetic characteristic, was of primary interest to JPL.

An investigation of available insulations resulted in the selection of Formvar as the preferred material. A study of methods to penetrate the insulation and make reliable welds was then started. The method Sippican used to penetrate the insulation consists of heating the upper electrode which causes the Formvar to soften and split under pressure.

With the selection of materials completed, Sippican established a thorough test program. This program, detailed in Section 5, consisted of pull testing 2500 sample welds at a 90° angle to the weld, with each sample

required to exceed the 50% strength level. A record of the test results is included in Appendix B.

As a result of the investigations described above, we recommend the use of Formvar coated, #34 AWG nickel wire with Alloy 142 pins as a combination of materials that will weld satisfactorily (demonstrate an average minimum tensile shear strength of 50%) using operational, production-line weld equipment with a modification for heating the top electrode. It is emphasized that these materials will provide the widest range of applications with the least manufacturing difficulty and, subsequently, the highest reliability.

Because of the interest to Jet Propulsion Laboratory and The Sippican Corporation's interest in exploring and developing new processes, materials and their applications, we are still working on the problems associated with welding insulated copper magnet wire. We will make the final results of our investigation available to JPL.

It is believed that this development will have immediate affect in many fields of electronics, and that its use will greatly stimulate the effective and early application of integrated circuits.

2. MATERIAL SELECTION AND VERIFICATION

The following section describes the selection and verification efforts required to establish the materials needed.

Original requirements for insulation, conductors, electrodes and pins are outlined, and the factors governing TSC's ultimate choice in each case, are explained.

2.1 Materials Selection

The following section lists the basic requirements to be met in selecting magnet wires and pins.

2.1.1 Conductor Requirements

The magnet wires selected for use in this program had to satisfy the following requirements:

- A. Must be insulated.
- B. Must be 0.0006 inch to 0.012 inch diameter.
- C. Must include a complete range of electrical properties.
- D. Must be compatible with pin materials.
- E. Desirable to have a lower melting point than pin material.
- F. Must be in the soft condition.
- G. Must have insulation 0.0004 inch thick or less.
- H. Insulation must permit heat to cause displacement flow or local burning.

I. The heated insulation should not cause voids, gas pockets or inclusions in the weld.

Based on these requirements the wire should be one of the following compositions:

Nickel	18% IACS conductivity
Copperweld	40% IACS conductivity
Silver Paladium	60% IACS conductivity
90% Silver 10% Cu	85% IACS conductivity
ETP Copper	100% IACS conductivity

Insulation materials that were investigated included:

Formvar or equivalent

Polyurethane

Enamels

2.1.2 Wire Verification

The verification procedures for the selected wires were as follows:

A. Copper

Copper was investigated primarily because of its high electrical conductivity, availability and ease of handling (bending). However, two disadvantages become apparent when using copper:

Poor yield and flex strength.

Inherently not a desirable welding material.

Sample welds were made with ETP copper and examined.

The examination uncovered a degradation in tensile strength of the copper wire

in the heat affected zone (the area adjacent to the weld). Another negative factor uncovered was a 30% deformation in the weld joint. TSC found, because of these two factors, that welds made with ETP copper could achieve only a 60% maximum tensile strength characteristic. The minimum of 50% tensile shear strength, established for this program, left only a 10% margin which is obviously inadequate. Further sampling was discontinued.

Another characteristic of copper is its high heat conductivity. This makes heating the intended weld area difficult for resistance welding in the range of wire sizes established.

B. Copperweld

The construction of the Copperweld wire is a 40% weight copper jacket over a core of S.A.E. 1010 mild steel. This material was selected for use because of its availability and 40% IACS electrical volume conductivity of copper.

Weld samples, made to various pin materials, revealed that although average strength was good, occasional welds were weak. Investigation revealed that the variations in copper jacket thickness and the lack of concentricity of the core material were the primary causes of this condition. A better wire product is needed. Such wire is available on special order from Metals & Controls, Inc.; however, deliveries are 8 to 12 weeks, which is considered prohibitive. It is concluded that although Copperweld joins with a higher average strength than solid copper, it will not weld as consistently as a solid material.

C. Copper Silver Zinc Alloy (Silvalory Hand)

"Trade name of American Platings."

This wire was selected for its electrical conductivity of approximately 60% IACS. However, due to its physical properties, it did not weld satisfactorily. The low melting point of 1350°F and the long plastic range tended to flatten the wire instead of welding it.

D. Coin Silver (90% AG 10% CU)

This material was investigated for its electrical volume conductivity of 80% IACS. The electrical conductivity increased the weldability of this alloy with respect to copper. However, its long plastic range made it difficult to weld without excessively flattening of the coin silver wire. Further investigation of coin silver was discontinued.

E. Nickel

Nickel, with an electrical volume conductivity of 18%, is known to have excellent weldability, a high melting point and narrow plastic range. When these characteristics are combined with an affinity for solid state bonding via diffusion, nickel becomes a ready choice.

It was discovered late in the program that the magnetic properties of nickel may cause problems in predicting the effect of its use in some electrical circuits.

2.1.3 Weldable Pin Requirements

The investigation into weldable pin requirements started with three materials being selected. None of these three were capable of satisfying the needs of the program; however, as explained in this section, an acceptable material was found.

The pins selected for use in this program had to satisfy the following requirements.

- A. Must allow welding on 0.050 inch centers.
- B. Must allow space for 0.020 inch between pins.
- C. Must be rigid enough to not crumble or buckle when welded on end.
- D. Must be gold plated 50 - 75 microinches to enhance welding and brazing.
- E. Must be of a material that is compatible with the wire.
- F. Desirable to have a similar or higher melting point than the wire.
- G. Desirable to have a low conductivity such that material is not heated during welding process.

2.1.4 Weldable Pin Verification

Initial investigation into welding the selected nickel wire to pins led us to evaluate three materials:

Nickel

Beryllium copper

Dumet

Pin size was set at 0.032 inch diameter 0.070 inch long.

A. Nickel

The difference in mass between 0.032 inch diameter x 0.070 inch long nickel pins and 0.0063 inch diameter nickel wire was so extreme

that almost all the heat was generated in the pins. Different electrodes of varying conductivity were tried in an attempt to compensate for this mismatch. This did not improve the welds and as a result investigation was discontinued.

B. Beryllium Copper

Beryllium copper pins were tried and the higher conductivity of this material made the mismatch problem worse. It too was abandoned.

C. Dumet

Dumet has a core of #142 Alloy, a very resistive alloy, with a copper jacket about it. The resistive core improved the mismatch and relatively good welds resulted. It was decided to make a sample run of 2500 welds using this combination. The run was stopped at 1750 welds after five samples had fallen below 50% in strength.

Analysis of the causes of failure was inconclusive for the five low reading welds; however, the fact that most welds failed at the weld interface was sufficient reason to establish that the mismatch problem still existed. However, the results did indicate the improvement in welding was due to the Alloy 142 and TSC decided to investigate further.

D. Alloy 142

A new pin was designed to compensate for the volumetric difference. The size of the pin was set at 0.080 inch long by 0.020 inch diameter with an 0.072 inch diameter head 0.008 inch high (reference figure 1).

The wire welded acceptably to the 0.020 inch end as 97.5% of welds broke in the wire outside the weld.

2.1.5 Insulation Selection

A survey of the materials commercially available for magnet wire insulation established three basic types.

Formvar and equivalent

Polyurethane and nylons

Enamel of all types

NOTE: Most manufacturers have discontinued nylon in favor of Polyurethane as a solder-through insulation. For this reason, nylon was eliminated.

A. Polyurethane

Tests indicated that Polyurethane could be penetrated at an electrode temperature of 250°C measured 3/4 of an inch from the tip.

B. Formvar

Formvar could be welded through at a temperature of 280°C measured as above.

C. Enamel

Enamel, however, could not be broken down or melted and was disqualified as an insulation.

D. Evaluation

Both polyurethane and Formvar are acceptable but Formvar being tougher was selected for the other phases of this study.

2.1.6 Electrode Materials

There is a basic problem when welding with a heated electrode in that most electrodes are copper or copper alloy in the precipitation

hardened or cold worked condition. Copper materials anneal at 500° to 1200°F, a range which overlaps the operating range of the heater and causes annealing of the electrode.

The small tip size of 0.020 to 0.030 inch causes very poor strength, permitting electrode bending. Also, even if the tips do not bend, they will erode fairly rapidly.

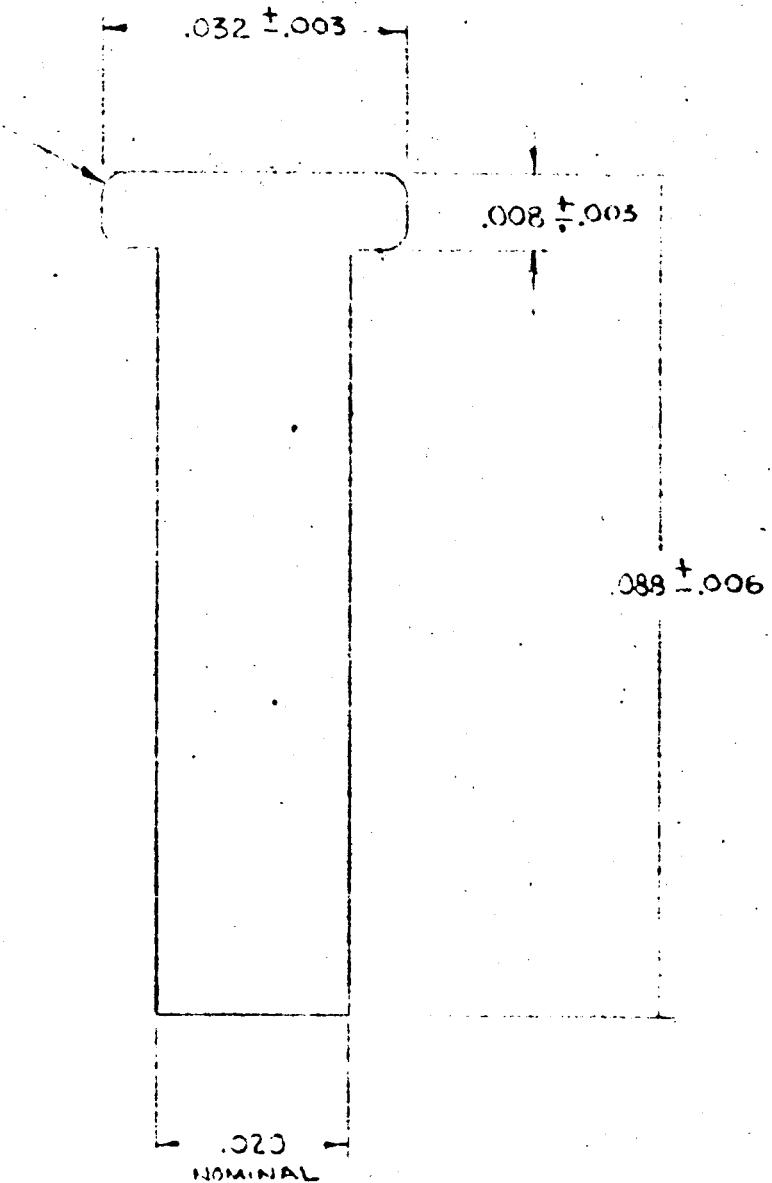
The requirement for a tougher non-eroding tip led us to try a molybdenum tipped electrode. This material has higher compressive strength and did not anneal or bend. However, erosion and sticking were excessive and electrode dressing was required too frequently.

Next was a 1/16" diam. 2% thoriated, tungsten rod tip in a RWMA class copper alloy rod. The tip was ground to 0.025 and welding was tried. Compressive strength was excellent, tips did not bend, and the high melting point prevented sticking and erosion.

We still had problems with oxidation of the copper alloy rod but this was minor. The electrode finally selected was the above-mentioned tungsten.

A production rig should use a 2% thoriated tungsten rod with a ground tip. This will withstand oxidation and still have good tip characteristic. A tip of solid tungsten carbide may be even superior but would be expensive.

SEE NOTE 1



NOTES

1. AS FORMED CONTOUR
ACCEPTABLE
2. MATL: #142 ALLOY

PIN, COLD HEADED

FIG. 1

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3. EQUIPMENT

3.1 Equipment Selection

In exploring and developing the essentially new technologies required to perform welding through insulation it was decided to work with modifications of capacitor discharge power supplies and weld heads of the low inertia, low pressure range, fast follow-up type. This equipment has been proven for electronics welding applications and offers known reliability and performance.

3.1.1 Power Supply

A Sippican Model 310 Varipulse Power Supply was selected for this program. The main reason for selecting this power supply is the range of pulse shapes available by varying capacity and utilizing the multi-taps built into the pulse transformer. Capacity ranges of 30, 60, 120 and 240 watt/seconds are available and, within each watt/second range, 6 transformer taps are available which vary the turns ratio of the transformer. Pulse width of 0.075 to 15 milliseconds can be obtained.

With long pulse widths, most of the heating takes place in the magnet wire. In the shorter pulses this condition is minimized.

3.1.2 Weld Heads

The weld heads used during this program were:

Hughes VTA 60

Sippican No. 218 DR.

Weldmatic 1032

Tweezerweld TW-I

The Tweezerweld TW-I weld head has too much inertia and poor pressure control under five pounds. Since the anticipated pressure range was one to four pounds, this weld head was not included in the final sample weld test runs.

The Hughes and Weldmatic weld heads were used interchangeably with The Sippican Corporation weld head during this program. However, because the small size (0.025") of the electrode made pressure overloading a critical factor, we decided to run the 2500 sample welds on The Sippican Corporation Model 218 DR weld head.

3.1.3 Electrodes

The electrode tip material requirements were discussed in Section 2.1.6. Centerless ground tungsten and tungsten alloy rods were selected for the tips, with copper alloy selected for the electrode shaft.

The tungsten tips and copper shafts combined to give the hardness, melting point, oxidizing, and annealing characteristics required at the tips, while maintaining sufficient heat transmitting capability.

3.1.4 Manual Wire Feed

The tool used for manual welding is shown on figure 2.

SKETCH - IX
(MANUAL WIRE FEEDER)

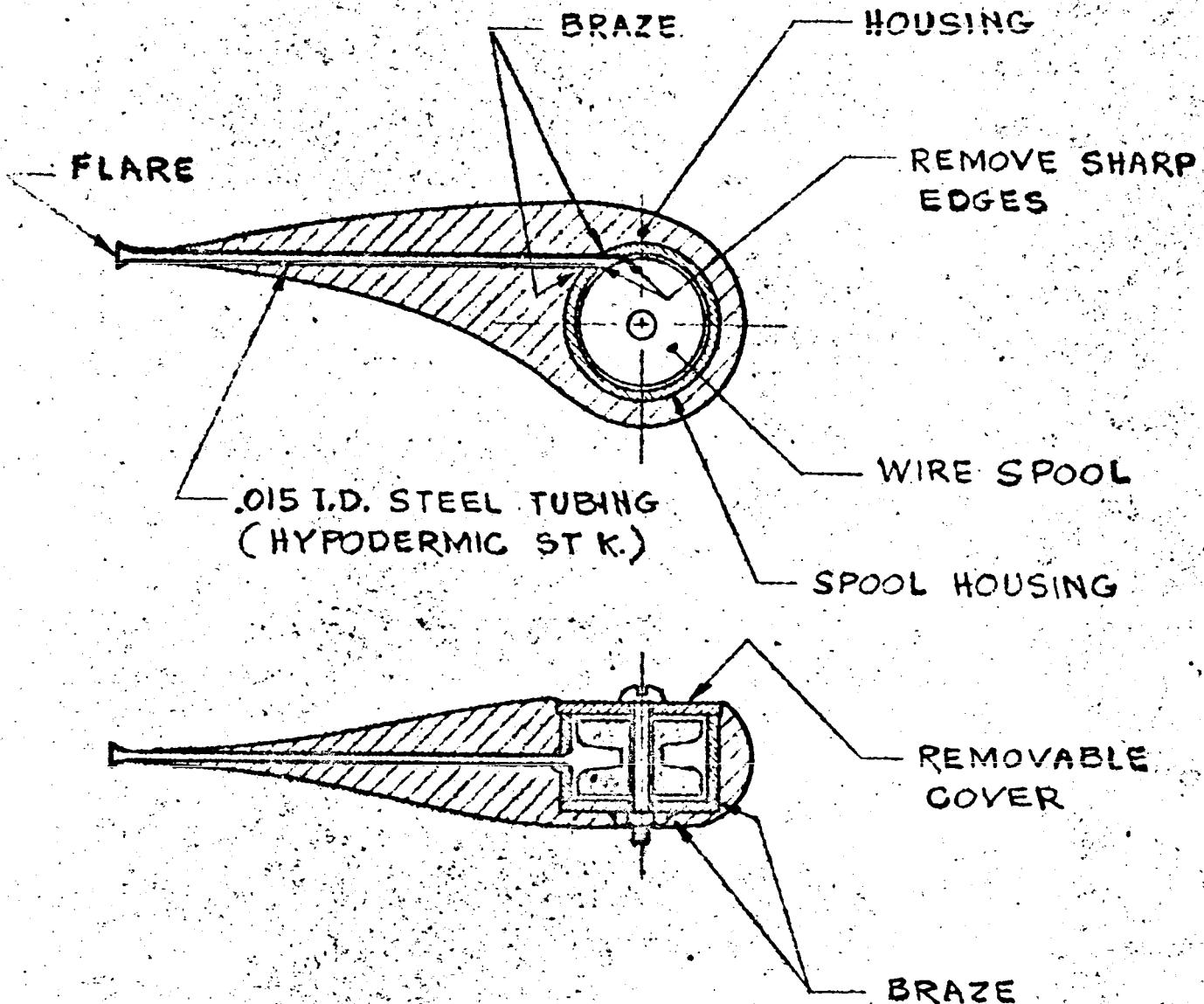


FIG. 2

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3-3

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17

4. INSULATION REMOVAL

Three possible methods of insulation removal were considered throughout the project. They were: electrode pressure, high frequency burning and electrode heating.

4.1 Electrode Pressure

Electrode pressure (regular welding) was tried and, although it worked at times, the current would not flow, or arcing occurred in most instances.

4.2 High Frequency Burning

The second approach consisted of applying high frequency to the two electrodes as the work was positioned between them. Just before the electrodes touched the insulation a high frequency power supply would discharge a pulse between the electrodes and an arc would bridge the gap. The arc would heat the wire and ignite the insulation resulting in 0.030 - 0.060" of insulation removal, which was of no value for an application requiring welding on 0.050" centers.

To minimize burning, the weld area was immersed in argon or nitrogen. The effect was dramatic. The high frequency pulse, instead of removing 0.030 - 0.060" of insulation caused pin holes large enough for the high frequency pulse to ground itself and prevented welding.

4.3 Electrode Heating

The third approach consisted of heating the upper electrode. Heating the electrode with a miniature gas torch worked well in the laboratory. For production use a more suitable heating system was obviously

needed. A hollow, electric heating element was designed and constructed to fit around the upper electrode. The heater, controlled by a Variac, was monitored by a thermocouple attached to the electrode. The construction and design of this equipment is described in the handbook. With this equipment the insulation was easily removed and excellent welding made possible.

5. TEST PROGRAM

Prior to running the 2500 sample welds, a mutually agreeable test program was established. The various test methods investigated and the particular test methods chosen are listed below.

5.1 Pure Tension

Most loading modes in actual welds possess some shear or peel moment. However, this test was discontinued for not being rigid enough.

5.2 Peel Tension - 90°

The results obtained by this method were erratic. The test itself was considered too severe and where it would be impossible to duplicate the method in actual applications (pull the wire perpendicular to the weld) this test was discontinued.

5.3 Tension Shear - 30°

Most loading modes in actual welds possess some shear or peel moment. However, this test was discontinued for not being rigid enough.

5.4 Peel Tension - 30°

Most loading modes in actual welds possess some shear or peel moment. However, this test was discontinued for not being rigid enough.

5.5 Tension Shear - 90°

This test method yielded consistent results and all breaks occurred outside the weld joint, in the heat affected zone. Also, the results obtained were in between the values of Sections 5.1, Pure Tension and 5.2, Peel Tension - 90°. The 90° tension shear test is also quite similar to the 90° torsional shear test method used in most cross-wire welding applications.

The results of the above investigation were discussed between L. Katzen of JPL and P. SanClemente of TSC and an agreement was reached to establish method 5.5, Tension Shear - 90°, as the test method for this program, as shown on Figure 3.

5.6 Sample Welds

The 2500 sample welds required by this program were made by one operator on one welding machine. The operator (qualified to the NASA level) has five years experience and was able to make 500 welds a day. The operator comments that once the process has been set up the welding is no more difficult than conventional welding.

Of all the welds made, eight were discarded by the operator for improper positioning. None of these welds blew up or severed. However, they did show signs of off center electrode placement, or tilted work positioning, shown by excessive cutting into the wire on one side. Another 43 welds were discarded when the pins became loose in the board and rotated during pull testing. An analysis of the data follows.

DATA ANALYSIS

1.	Samples welded	2,551
2.	Pull tested	2,500
3.	Discarded by operator	8
4.	Discarded when pin rotated	43
5.	Average strength	1.85 lb.
6.	Highest weld strength	2.25 lb.
7.	Lowest weld strength	1.10 lb.

8.	Standard Deviation	.1455 lb.
9.	3 σ Limit High	2.30 lb.
10.	3 σ Limit Low	1.40 lb.
11.	X-3 σ % of weaker material	64.5%
12.	X-5 σ % of weaker material	50%
13.	Wire Strength	2.2 lb.

CALIBRATIONS

Average weld strength

$$\frac{\sum x}{n} = \text{Avg. St. } \bar{x} = \frac{4678.65}{2500} = 1.85 \text{ lb.}$$

Standard deviations

$$\sigma_x = \sqrt{\frac{-2}{\sum \frac{2(x-\bar{x})}{n}}} = \sqrt{\frac{52.7765}{2500}} = 0.1455 \text{ lb.}$$

3 Standard deviations % - JPL Method

$$\frac{\bar{x} - 3\sigma}{y} = \frac{1.85 - 3(.15)}{2.20} = \frac{1.40}{2.20} = 65\%$$

5 Standard deviations % - TSC Method

$$\frac{\bar{x} - 5\sigma}{y} = \frac{1.85 - 5(.15)}{2.2} = \frac{1.1}{2.2} = 50\%$$

SKETCH - X

(90° TENSILE SHEAR TEST)

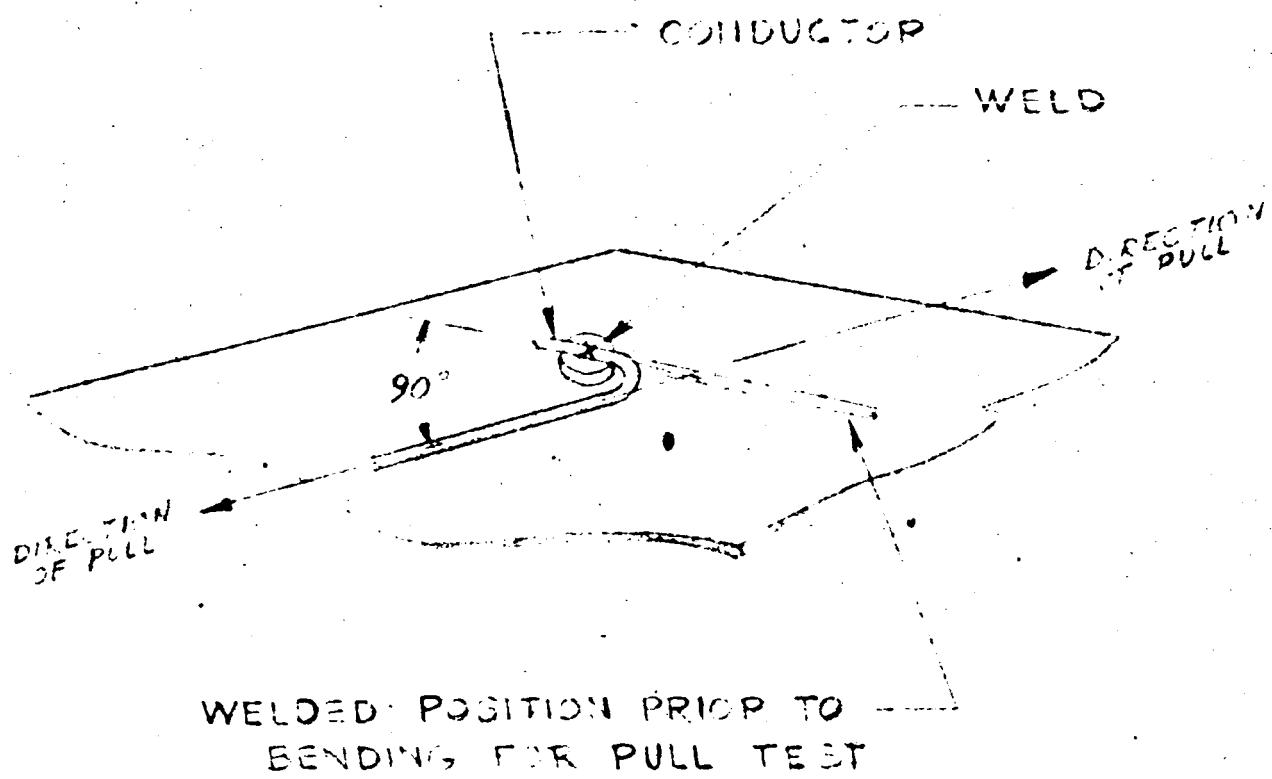


FIG. 3

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6. AUTOMATIC WELDING

A method for automating a random point-to-point positioning system for resistance welding is described in this section.

This method is ideal for hybrid digital-analog circuitry and utilizes data stored on punched tape. Other possibilities are punched card, photo cell plano-graph tracing, magnetic tape or semiautomatic methods.

Factors to consider when determining the feasibility of automating this process are the positioning accuracy required, resolution of the equipment to be used, repeatability desired within the operation and the cost trade offs.

6.1 Equipment Requirements

The equipment must be capable of satisfying the following requirements:

A. X and Y axes movement

For accurate movement, at increments of 0.050 inches, along the X and Y axes.

B. Z axis movement

For movement when indexing and to allow the lower electrode contact with the workpiece.

C. Weld Head

Capable of welding Formvar insulated wire to contact pins.

D. Wire Feed Mechanism

Capable of 60° rotation and suitable wire feeding for point-to-point welding.

E. Wire Cut Mechanism

F. Programmer

For programming the total functions of the machine.

6.2 List of Definitions and Abbreviations

1. Frame positioner - a device which accepts frames and transmits a coincidence electrical signal when the frame has been positioned correctly.
2. Tape - perforated strip paper tape.
3. Tape Reader - translates tape perforations into binary data.
4. Decoder - device for separating along and across motion digital data.
5. DAC - Digital-to-analog converter.
6. CT - Synchro control transformer.
7. FUS - follow-up-servo.
8. SC - slip clutch.
9. SCA - slip clutch adjustable.
10. MCB - magnetic clutch brake.
11. R - electrical resolver.
12. P - potentiometer.
13. Q - weld head angular position.
14. Control Unit - control panel enabling automatic or manual operation.
15. A - isolation amplifier for impedance matching.

6.3 Automatic Control Operation Sequence

1. Tape with stored data prepunched previously is inserted into type header.
2. Coded data format consists of repetitive series of blocks of data for each point, together with control data.
3. Tape reader reads out binary data and transmits to decoder.
4. Decoder - separates data for each orthogonal axis.
5. The DAC - converts the digital pulses into three-wire synchro voltage and two wire analog voltage.
6. The synchro control transformer takes this voltage and feeds a follow-up-servo.
7. The position taken up by the servo and hence the x worm drive is used to null out the input of the control transformer.
8. The slip clutch is used to protect the servo motor from excessive loads.
9. In a similar manner, the y axis data is processed.
10. Simultaneously, as x and y data are being processed, the weld head is rotated by a follow-up servo which computes angular position from the rectangular position from the rectangular coordinate information.
11. At the same time, the polar distance vector is generated by a similar follow-up servo. Thus, the wire fed out is directly proportioned to the distance travelled by the weld head.

12. After the coordinate data has been fed into each axis, the lower electrode is moved into position below the desired pin by means of a motor and eccentric cam.

13. After the lower electrode moves into position, the upper electrode is caused to move down against the wire to be welded. After a certain time and appropriate pressure has been exerted, the welding machine is caused to fire.

14. Whenever the program calls for the wire to be cut, a solenoid operated retractable shear is extended to perform this function.

15. After the weld operation has been completed, the tape reader is commanded to process the next set of coded information.

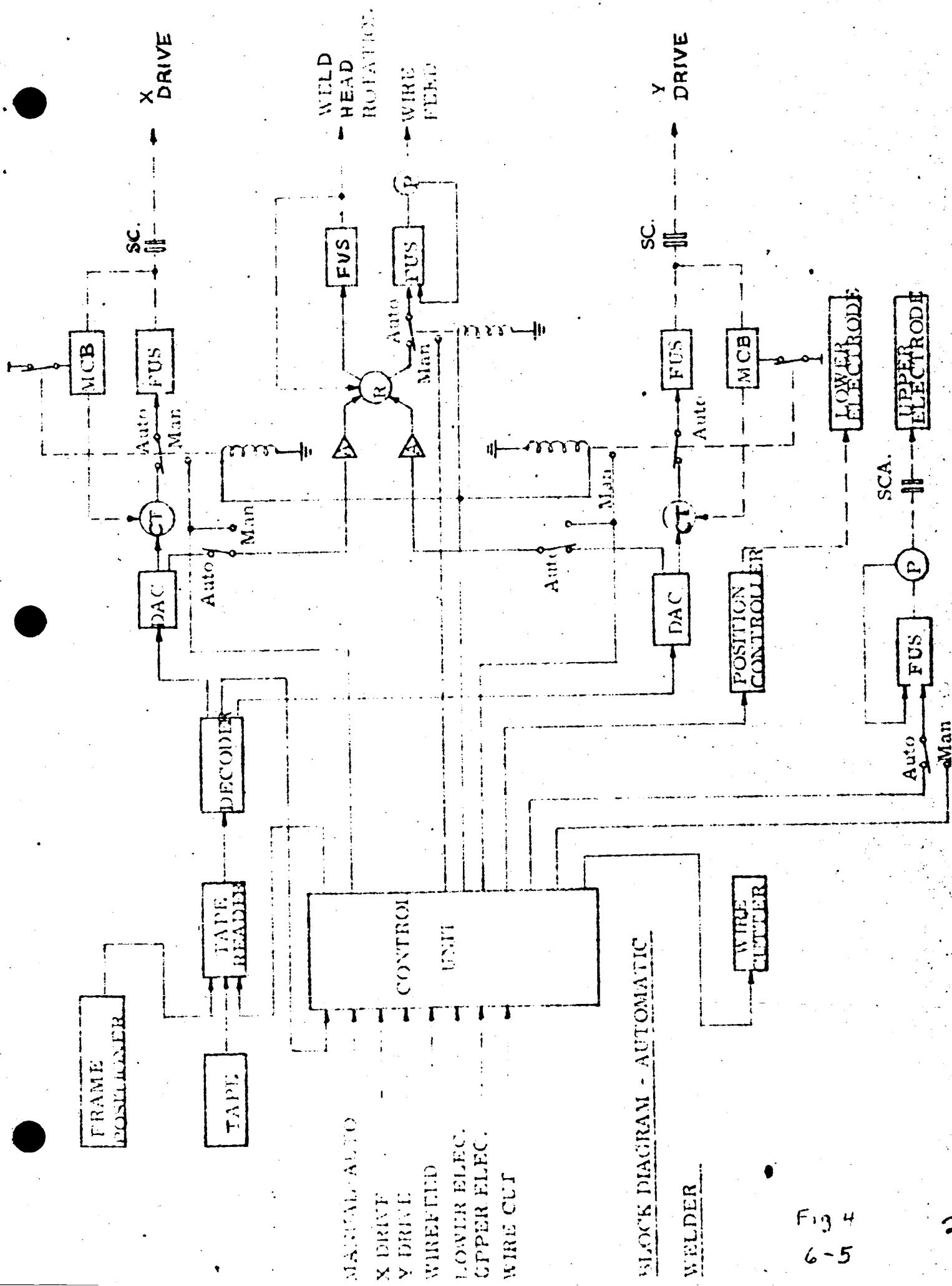
6.4 Manual Control

1. When manual control is selected at the control unit, the x and y servos are disengaged and are driven open loop by a dual mode joy stick. This joy stick control simultaneously links each of two potentiometers which are tapered logarithmically, thus allowing maximum sensitivity when the final position has been achieved.

2. The weld head is rotated automatically as a direct function of x and y.

3. However, wire feed-out is manually controlled.

4. Under manual control, the positioning of all electrodes and the cutting of wire are manually controlled.

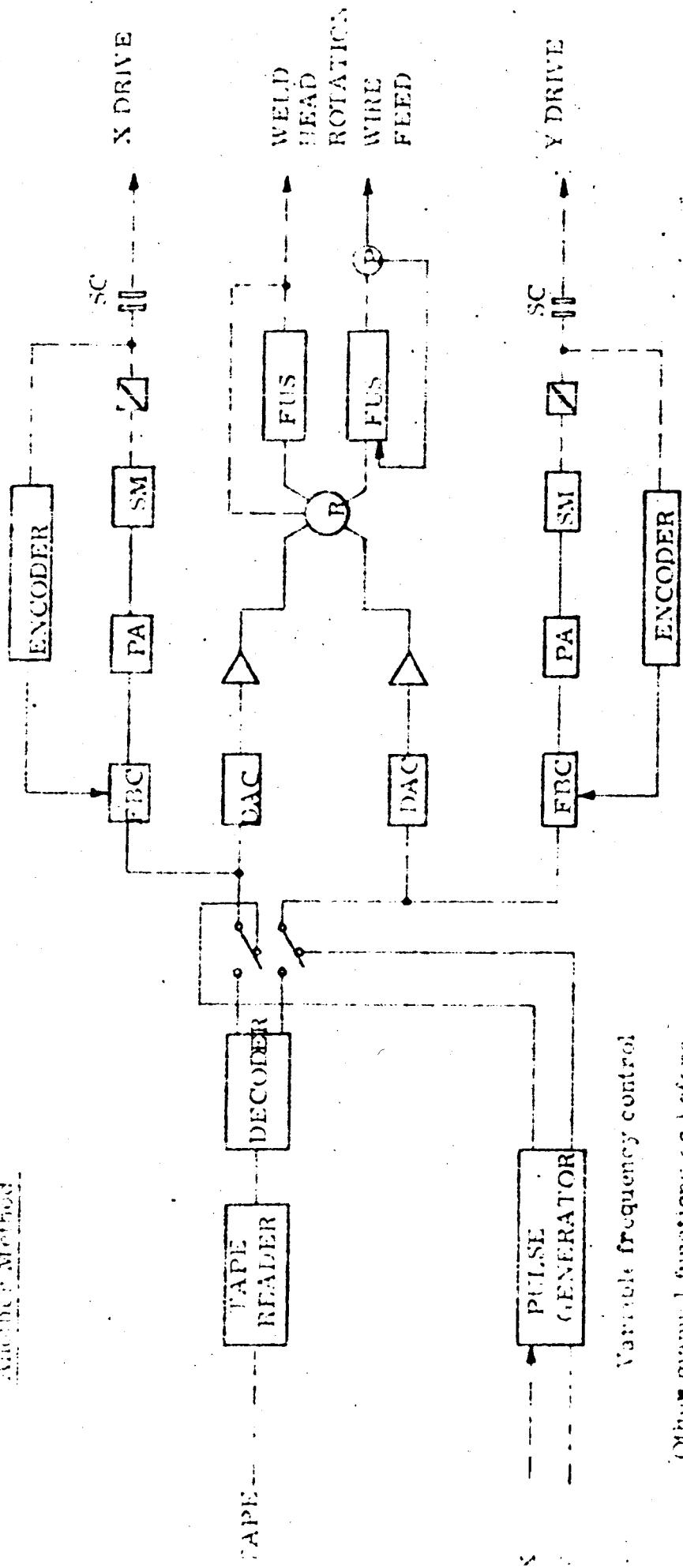


BLACK DIAGRAM - ATOMIC

WELDER

Fig 4
6-5

Analog Method



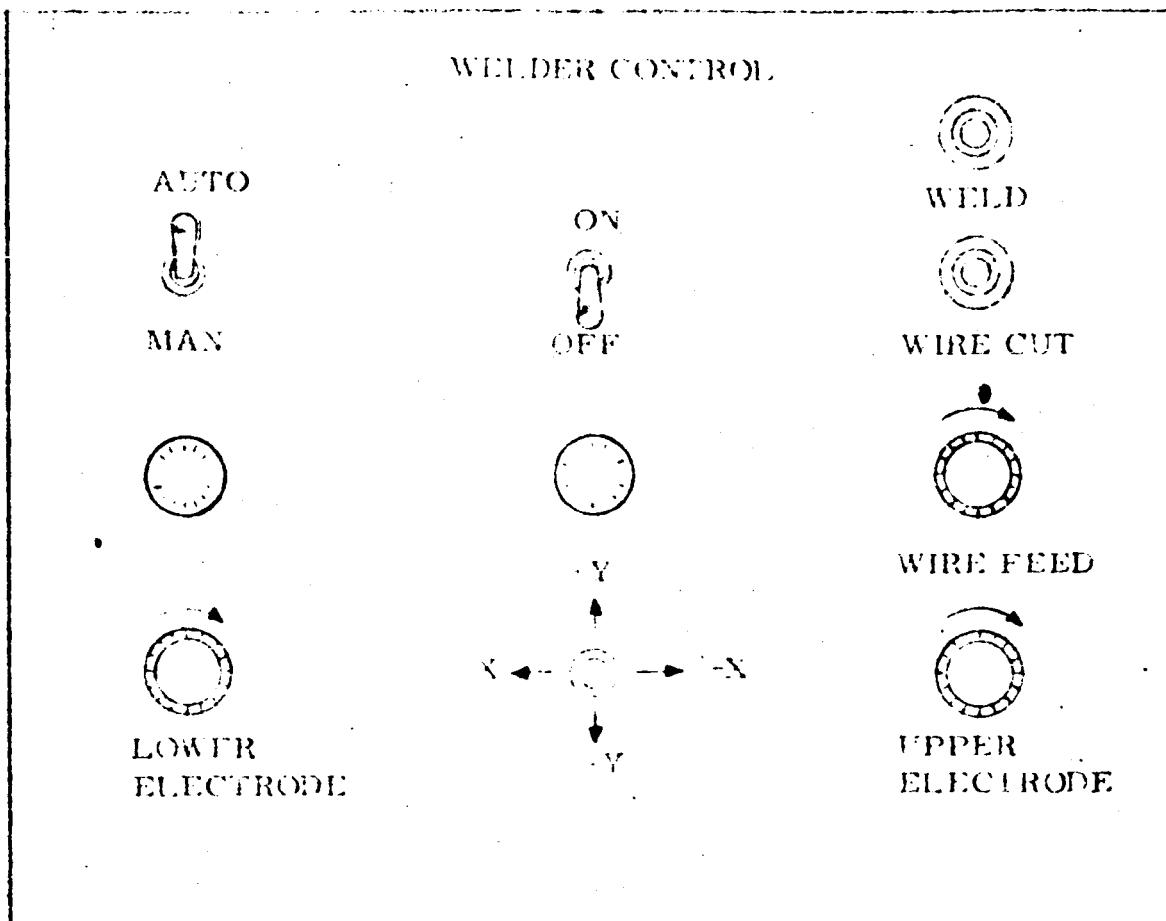
Variable frequency control

Other manual functions as before

VFC forward backward center

PA pulse amplifier and drives

SM stepper motor



Lamp frame position.

Lamp coordinate position redundant.

Fig 6
6-7

30

6.5 General

The most critical alignment problem is positioning the wire directly beneath the welding electrode. To accomplish this the weld head and the wire feed will be built in rigid alignment. To revolve the wire feed the weld head will be mounted on a ring gear capable of 360° motion. The ring gear assembly will be mounted on an X-Y axis carriage built on the U-frame above the work area. The lower electrode will be attached to the X-Y axis carriage and curve beneath the work area. This arm must have free travel beneath the work and be capable of raising and lowering to contact pins. This will be done by a toggle switch, or eccentric motion cam linked to an electric solenoid for actuation.

Basic construction will be a three-tiered angle iron frame of reinforced welded construction. Machined ways will be bolted to the second tier for the automatic X-Y stage to ride on.

The first tier is a machined plate with a recessed window seat. In the window seat, various flush fitting windows are seated capable of holding work of varying size. This window requires precision, adjustable stops and the frames require precision loading to guarantee the alignment of the pins to the electrode.

The power supply and heating controls are mounted on the third tier. The power supply must be equipped with either a rotating disk and brush, 360° rotational connector, or a coiled cord capable of 2 to 3 revolutions without binding.

The weld head is mounted to the end of a solid rod or built into the rod. The wire feed drive is attached to the rod, the wire spool mounted above the X-Y table, and they feed wire to the drive unit, through a teflon tube. A teflon guide, guides the wire to within 0.030" of the electrodes. The wire unit is set so when the weld heat retracts, the wire feed retracts about 1/2 as much, thus protecting the wire from electrode heat while maintaining close alignment of wire to electrode.

The unit is equipped with a stereo microscope on a swing mount. The microscope is used to manually position the X-Y assembly before locking into tape program.

Programming a machine to weld a matrix or grid will call for shortest wire paths being done first. Special programming will be required to place wires so they do not cover pins not yet welded.

All motions should be equipped for manual operation by momentary contact buttons, or foot switches.

Each program should include a check of alignment by running the unit on the X-Y table through a cycle taking it to the corner pins.

This check should be verified by the stereo binocular wire feed. Speed will have to be an integrated function of X motion and Y motion.

A typical programmed cycle would be as follows:

1. Manually jog wire 1/8 inch approximately.
2. Clip wire with automatic cutter.
3. Index wire - correct length automatically

4. Index X-Y carriage to correct pin location.
5. Index to 0 - 360° location.
6. Weld
 - A. Lower electrodes raises and locks.
 - B. Upper electrode lowers and assumes correct pressure.
 - C. D.C. current flows.
 - D. Electrodes retract.
7. X-Y indexing to next location while head assumes new angle

to position wire directly over pin number two; wire feed runs while X-Y motions are going.

8. Make weld number two.
9. Proceed to pin number three or clip after number two.

6.6 Automatic Welding Machine Parts List

1. Sippican Model 310 power supply - Supplies power for welding magnet wire to contact pins.
2. Heating control - Supplies power for electrode heater, contains temperature controller and thermocouple reading of tip temperature.
3. Frame - Angle iron welded reinforced frame to house automatic welder.
4. Controls - Manual controls for aligning head prior to start of automatic sequence.
5. Table - Work table with window cutout. For locating workpiece frames of various inside dimensions, depending on workpiece size.

6. U-Frame, Subassembly - One function of this subassembly is to house the lower electrode and toggle assembly that is powered by an electric solenoid, which gives the lower electrode the up and down motion required for indexing pin to pin.

7. Lower Electrode.

8. Wire feed - A precision miniature wire feed with teflon nozzle to guide wire. Contains a miniature drive mechanism and linkage to raise wire feed one half as much as weld head for indexing and to keep wire away from hot electrode tip.

9. Wire feed spool - Rolls of wire for welding are mounted on top of assembly, away from welding area.

10. Wire feed guide - Teflon tube runs down through weld head rod to wire drive mechanism.

11. Cutters - A manual, or automatic scissors type retractable cutter will be mounted on lower side of weld head rod. When brought forward it will cut wire 0.020" from welded area.

12. Welding electrode - A tungsten alloy tip is recommended for welding.

13. Electrode heater - A resistance heating element with a stainless steel inside tube diameter for electrode changing. Should have stainless steel jacket around the heating element and give off enough heat to maintain tip at 400°C.

14. X-axis carriage bed - Mounted on two precision guide ways. This carriage must be able to support the entire weld head assembly and be maintained at 0.001 TIR when table is run from left stop to right stop.

15. Gear drive - Precision worm gear drive should have endless ball race. (Saginaw type).

16. Y-axis carriage - Mounted on top of X-axis table, drives weld head back and forth along Y-axis.

17. X-axis carriage bed - Precision ways for Y-axis carriage see details for X-axis.

18. Gear drive - Precision worm gear, drive for Y-axis carriage.

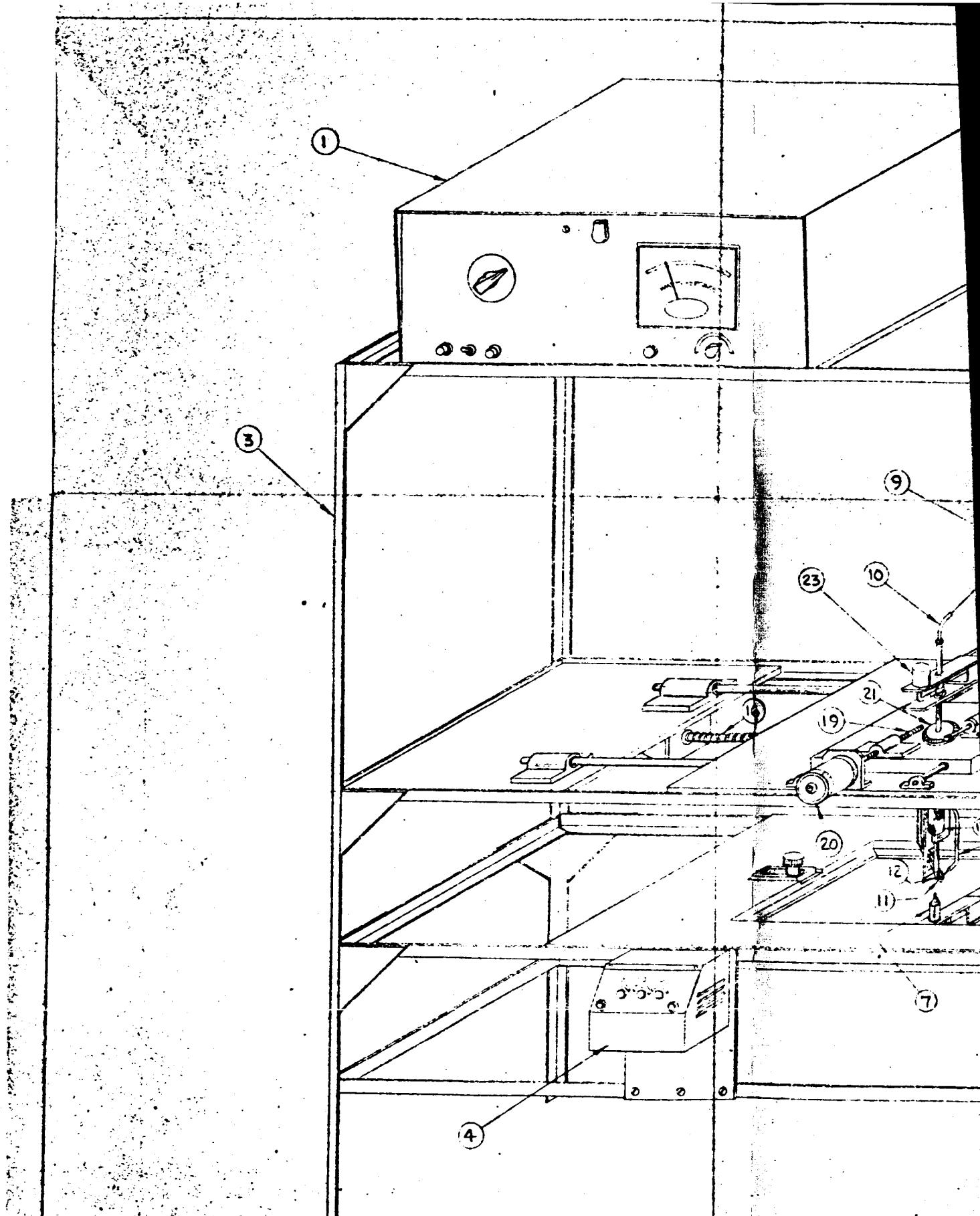
19. Drive Motor - For Y-axis variable speed shunt wound motor, with independent speed controller.

20. Table mount - Rotary table mount on ring gear driven by bevel gear, allows wire feed positioning over 360°.

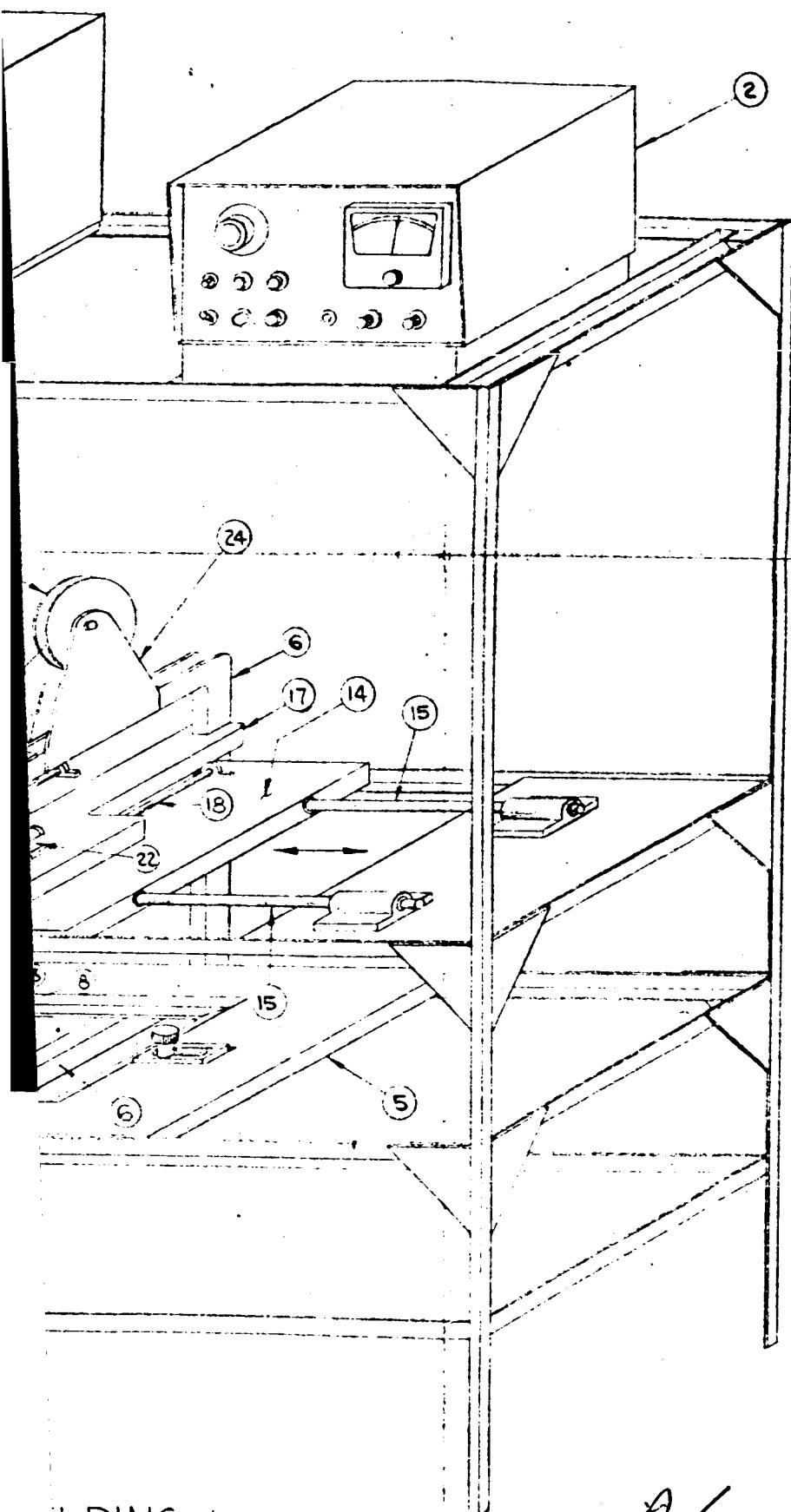
21. Motor for rotary table.

22. Motor or solenoid control - For raising and lowering weld head, equipped with slip clutch for varying weld pressure.

NOTE: All electric motors and solenoids would feed to a central control for manual operation and then to a complete panel equipped with a numerical punched tape control system.



CONCEPTUAL AUTOMATIC WE
MACHINE FOR INSULATED



LDING
NIRE

2

FIG 7

FOR JPL
DATE FEB 3, 1965
SK 207289

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7. APPENDIX

Included in this appendix is information relating to the program. This information includes conductor properties and comparisons, test results and the weld schedule used.

7.1 Conductor Comparisons

Sections A, B and C contain the properties for copper, alloy 142 and nickel. The information listed in these sections was obtained from the Metals Handbook, Volume 1, as referenced by number.

7.1.1 Softening Temperature

Copper - 400 to 800°F; nickel - 1200°F min.

7.1.2 Fatigue Strength (Modules of Elasticity)

Copper - 15×10^6 ; nickel - 30×10^6

The higher value of nickel for this property accounts for the superior flex strength of nickel wire over copper wire.

7.1.3 Tensile Strength

Copper - 34,000 psi avg.; nickel - 50 to 8000 psi

7.1.4 Yield Strength

Copper - 4,800 psi; nickel - 10 to 30,000 psi

7.1.5 Elongation

Copper - 38.5%; nickel - 30 to 50%

7.1.6 Conductor Properties Summary

These factors, combined with our own experience, prove that copper has a failure rate twice that of nickel. Our experience with 65,888

welds made with copper has shown 77 failures, all due to handling. This compares to 57 failures in 106,776 nickel, nickel alloy welds. When computed, these results show a two to one failure rate favoring nickel over copper.

7.1.7 Copper Wire Investigation

With the above information already established, our continuing investigation into copper has uncovered the following details:

(a) The high conductivity of copper increases the temperature required to remove Formvar to approximately 450°C. At this temperature, copper tends to flatten when welded.

(b) The composition and configuration of the pin are critical. It now appears that a pin having high resistivity, low volume and a cylindrical interface will be required.

(c) The minimum strength requirement of 50% established for nickel will have to be reduced to 40%.

(d) The angle that the wire is pulled at, during the weld sampling test program, will have to be reduced from 98° to 45°.

7.1.8 Comparison Results

An examination of the properties of nickel and copper makes it clear that nickel is the better material, unless there are controlling conditions which mitigate against its use. Two conditions are obvious: first, where the magnetic qualities of nickel could interfere either with the behavior of the circuitry or where the entire system should be non-magnetic; secondly, some circuitry involves sufficient current levels that nickel's poorer conductivity could be damaging. Failing these conditions, nickel's superior strength and

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toughness, coupled with its more tolerant behavior during welding, would make it a better material.

The Sippican Corporation is continuing its studies of copper welding through insulation, and will make new information available to Jet Propulsion Laboratory.

APPENDIX A
ELECTROLYTIC TOUGH PITCH
COPPER (ETP)

(99.95 Cu - 0.040)

1. ELECTROLYTIC COPPER

Precautions in use. This copper is subject to embrittlement when heated in a reducing atmosphere as in annealing, brazing or welding at temperatures of 700°F or above, and in hydrogen or carbon monoxide is present, embrittlement can be rapid.

Density at 68°F (20C). 8.89 g per cu cm (0.321 lb. per cu in.).

⁴⁸ Density at 1981°F (1083 C). Solid, 8.32 g per cu cm; liquid, 7.93 g per cu cm.

Density versus percentage deformation. See graphs. It is generally considered that cold working decreases density. Density changes in cold work may be positive or negative, depending on the type of cold work and conditions of annealing.⁴

Liquidus temperature 1981°F (1083°C)

Solidus temperature 1949°F (1065°C)

Boiling Point 4703°F (2595°C)

Volume thermal expansion (liquid). 1931° to 2363°F (1083° to 1295°C).

¹² 0.00019 per °C.

Specific heat at 68°F (20C). 0.092 cal/g/°C

Latent heat of fusion. ⁴⁹ 48.9 cal per g

Latent heat of vaporization. ⁵⁰ 1150 cal per g

Thermal conductivity at 68 F (20C). 0.934 cal/sq cm/cm/sec/ $^{\circ}$ C
(adjusted to correspond to an electrical conductivity of 101%).

Heat of oxidation.⁵¹ Cu₂O, 334 cal per g; CuO, 607 cal per g

Recrystallization temperature.¹⁴ It varies from about 390 to 620 F (200 to 325C) depending on the nature of impurities and hardness of the material. See graphs. Hard wire loses strength slowly at lower temperature.⁵⁴

Electrical conductivity. About 101% IACS, annealed.

Electrical resistivity at 68F (20 C). 1.71 microhm-cm, annealed.

Electrical resistivity (liquid) at 2012 F (1100 C). 21.52 microhm-cm.

Temperature coefficient of electrical resistivity at 68 F (20C).

0.00393 per $^{\circ}$ C for 100% conductivity; 0.00397 for 101% conductivity.

Electrolytic solution potential versus hydrogen. C++, -0.344 volts; Cu+, -0.470 volts.

Hydrogen overvoltage.⁴⁶ 0.23 (dilute H₂SO₄). It varies with current density.

Hall effect.²⁴ R=0.52 x 10⁻¹² volt-cm per ampere-gauss. Experimental figures vary from -0.428 to 0.547 x 10⁻¹².

Magnetic susceptibility.⁵² -0.080 x 10⁻⁶ cgs units per g at 68 F (20C).

Thermal neutron absorption cross section.⁵² CU₆₃ 0 = 2.8 barns.

Poission's ratio.¹⁸ 0.33 ± 0.01.

Modulus of elasticity. 17,000,000 psi. This modulus is "directional"

in rolled sheet.²⁹ It decreases with increasing temperature.^{30, 31}

Minimum creep rate at 400F (204C). Annealed (by interpolation)³⁷

5000 psi, 0.042% per 1000 hr

6700 psi, 0.10% per 1000 hr

9000 psi, 0.21% per 1000 hr

Consequences of exceeding impurity limits. Nominal oxygen content about 0.04 % (range 0.01 to 0.07%).

Sulfur causes spewing and unsoundness, and is kept below 0.003% in ordinary refinery practices.

Selenium and tellurium are usually considered undesirable impurities, but may be added to improve machinability.

Bismuth creates brittleness in amounts greater than 0.001%. Bismuth is rarely detected in American copper.

Silver has little effect on mechanical and electrical properties, but does raise the recrystallization temperature and tends to "fine" the grain.^{1, 41, 42, 43}

Iron, as present in commercial copper, has no effect on mechanical properties, but even traces of iron may cause ferromagnetism.⁴⁷ Hot working temperature range, 1400 to 1750 F (750 to 950 C).

Shortness temperature. None.

TABLE 1. TYPICAL MECHANICAL PROPERTIES OF ELECTROLYTIC
TOUGH PITCH COPPER

Section in.	Temper	Tensile strength psi	Yield strength, psi (a)	Elon- gation in 2 in. %	Rockwell hardness F B 30T	Shear strength psi	Fatigue strength psi 10
0.080	Annealed	34,500	4,800 (b)	38.5 (c)

2. ALLOY 142

Alloy 142, an alloy containing 41% Nickel, has approximately the same coefficient of expansion as that of 7050 glass for many years. It is also useful as a thermostatic metal for higher temperatures than those at which Nilvar is used. A popular use is as terminal caps for all automatic beam lamps.

Analysis:	Nickel	40.5-41.5%
	Carbon	.02% Max.
	Silicon	.25% Max.
	Iron	Balance
Specific Resistance:		70 microhm cm 420 ohms/cmf
Nominal Temperature Coefficient of Resistance		.0025 (0° - 100°C)
Thermal Conductivity Watts-Sec. Per cm Per °C		.160
Approximate Melting Point °C		1425
Coefficient of Linear Expansion		20° - 100°C 4.8×10^{-6} 20° - 400°C 5.3×10^{-6} 20° - 1000°C 13×10^{-6}

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Tensile Strength at 20° C	<u>Min.</u>	<u>Max.</u>
Pounds per sq. in.	70,000	150,000
Specific Gravity		8.12
Pounds per cubic inch		.293

"A" NICKEL

(99.4% Ni + Co)*

3. "A" NICKEL

Density at 68F (20 C). 8.885 g per cu cm (0.321 lb per cu in.)

Liquids temperature. 2635 F (1446 C)

Solidus temperature. 2615 F (1435 C)

Thermal expansion 77 to 212 F (25 to 100 C) 0.0000133 per °C.

Specific heat 32 to 212 F (0 to 100 C). 0.13 cal per g

Latent heat of fusion. 73 cal per g

Thermal conductivity 32 to 212 F (1 to 100 C). 0.145 cal/sq cm/cm/°C/sec (420 Btu/sq ft/hr/°F/in.)

Recrystallization temperature. 1112 F (600 C)

Electrical conductivity. 18% IACS

Electrical resistivity at 68 F (20 C). 9.5 microhm-cm.

Temperature coefficient of electrical resistivity 68 to 212 F (20 to 100 C). 0.00474 microhm-cm per °C Electrical resistivity versus temperature. See graph.

Initial permeability. 100 gausses Maximum permeability. 600 gausses.

Coercive force. 3.4 oersteds.

Saturation magnetization (B - H). 6100 gausses.

Hysteresis loss at saturation. 3000 ergs per cu cm per cycle.

Magnetic transformation temperature. 680 F (360 C)

*Compiled by Huntington Alloy Products Div., The International Nickel Co., Inc. Nominal composition includes 0.2 Mn, 0.15 Fe, 0.1 Cu, 0.1 C, 0.05 Si, 0.0005 S.

Mechanical properties. See Table 1

Modules of elasticity. Sand cast, 21, 500,000 psi; annealed, 30,000,000 psi.

Charpy. Annealed, 222 ft-lb; hot rolled, 197 ft-lb; cold drawn, 195 ft-lb; sand cast, 60 ft-lb.

Izod. Annealed, hot rolled, or cold drawn, 120 ft-lb; sand cast, 85 ft-lb.

Strength in double shear. Annealed, 52,300 psi; half hard, 57,550 psi; hard, 75,300 psi.

Fatigue limit for 100,000,000 cycles. Annealed, 24,000 psi; hot rolled, 30,000 psi; cold drawn, 42,500 psi.

Minimum creep rate. At 750 F (400 C): not rolled, 10,000 psi for 1% per 10,000 hr; at 800 F (425 C); cold drawn, 24,000 psi for 1% per 10,000 hr.

Casting temperature range (sand). 2750 to 2900 F (1510 to 1595 C) Alloying. Add silicon and manganese as metals.

Preferred deoxidizer. Magnesium

Type of flux. Lime-fluorspar

Precautions in melting. Do not superheat.

Hot working range. 1200 to 2300 F

Annealing temperature range. 1200 to 1400 F (650 to 760 C)

Maximum reduction between anneals. 90%.

Suited for forming by all methods of hot and cold working.

Precautions in forming. Do not heat in sulfidizing atmospheres.

Joining.

Soft solder with Pb-base and Sn-base alloys, acid flux.

Silver solder with phosphorus-free silver brazing alloys, fluoride flux, reducing flame.

Braze with phosphorus-free and lead-free alloys, fluoride flux, reducing flame.

Oxyacetylene weld with nickel, no flux, reducing flame.

Metal-arc weld with nickel, proprietary flux.

Resistance welding. All methods are satisfactory.

TABLE 2. TENSILE PROPERTIES AND HARDNESS OF NICKEL
(99.4% Ni + Co)

Condition	0.2% yield strength	Tensile strength, 1000 psi	Elongation		Reduction of Area %	Brinell hardness %	Hardness Rockwell B
			in 2 in.	%			

SECTION 3

RELIABILITY ANALYSIS

To prove the requirements of Contract No. 950836 with regard to strength, the following data is submitted as proof of the successful meeting of 50% or greater strength as compared with the weaker material. This was accomplished by welding and testing 2500 consecutive welds and not experiencing any welds that pull tested less than 1.1 lbs when subjected to a 90° tensile shear test. The basic wire tensile tested at 2.2 lbs.

ANALYTICAL SAMPLE

No. Tested - 2500

Test Method - 90° Tensile Shear

Sample No.	Tensile Test (x)	Difference (x - \bar{x})	$(Diff)^2$ $(x - \bar{x})^2$	Sample No.	Tensile Test (x)	Difference (x - \bar{x})	$(Diff)^2$ $(x - \bar{x})^2$
1	1.8	.05	.0025	32	1.5	.35	.1225
2	1.85	.0	-	33	2.05	.2	.04
3	1.75	.1	.01	34	1.7	.15	.0225
4	1.75	.1	.01	35	1.6	.25	.0625
5	2.1	.25	.0625	36	1.75	.1	.01
6	2.0	.15	.0225	37	1.6	.25	.0625
7	1.8	.05	.0025	38	1.65	.2	.04
8	1.95	.10	.01	39	1.75	.1	.01
9	1.8	.05	.0025	40	1.5	.35	.1225
10	1.85	.0	-	41	1.9	.05	.0025
11	1.95	.1	.01	42	2.0	.15	.0225
12	1.8	.05	.0025	43	1.85	.0	-
13	1.7	.15	.0225	44	2.05	.2	.04
14	1.7	.15	.0225	45	1.95	.10	.01
15	1.8	.05	.0025	46	1.55	.30	.09
16	1.8	.05	.0025	47	1.6	.25	.0625
17	1.75	.1	.01	48	1.9	.05	.0025
18	1.6	.25	.0625	49	1.65	.2	.04
19	1.85	.0	-	50	1.9	.05	.0025
20	1.95	.1	.01	51	1.8	.05	.0025
21	1.9	.05	.0025	52	1.5	.35	.1225
22	2.0	.15	.0025	53	1.8	.05	.0025
23	1.75	.1	.01	54	1.6	.25	.0625
24	1.95	.1	.01	55	1.7	.15	.0225
25	1.85	0	-	56	1.45	.40	.16
26	1.9	.05	.0025	57	1.65	.2	.04
27	1.75	.1	.01	58	1.75	.1	.01
28	1.95	.1	.01	59	1.65	.2	.04
29	1.9	.05	.0025	60	1.95	.1	.01
30	1.6	.25	.0625	61	1.7	.15	.0225
31	1.75	.1	.01	62	2.1	.25	.0625

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No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
63	1.75	.1	.01	111	1.75	.1	.01
64	1.75	.1	.01	112	2.1	.25	.0625
65	1.9	.05	.0025	113	1.8	.05	.0025
66	1.75	.1	.01	114	1.65	.2	.04
67	1.85	.0	-	115	2.-	.15	.0225
68	1.9	.05	.0025	116	1.7	.15	.0225
69	1.8	.05	.0025	117	2.1	.25	.0625
70	1.65	.2	.04	118	1.75	.1	.01
71	1.6	.25	.0625	119	1.75	.1	.01
72	1.85	.0	-	120	1.7	.15	.0225
73	1.8	.05	.0025	121	1.85	.0	-
74	1.85	.0	-	122	1.85	.0	-
75	1.95	.1	.01	123	1.8	.05	.0025
76	1.75	.1	.01	124	1.6	.25	.0625
77	1.95	.1	.01	125	1.8	.05	.0025
78	1.7	.15	.0225	126	1.6	.25	.0625
79	1.75	.1	.01	127	1.9	.05	.0025
80	1.85	.0	-	128	2.-	.15	.0225
81	2.-	.15	.0225	129	1.85	.0	-
82	2.-	.15	.0225	130	1.95	.1	.01
83	1.95	.10	.01	131	1.95	.1	.01
84	2.05	.2	.04	132	1.75	.1	.01
85	2.-	.15	.0225	133	1.95	.1	.01
86	1.85	.0	-	134	1.5	.35	.1225
87	1.7	.15	.0225	135	1.75	.1	.01
88	1.9	.05	.0025	136	1.6	.25	.0625
89	1.85	.0	-	137	1.65	.2	.04
90	1.75	.1	.01	138	1.8	.05	.0025
91	1.8	.05	.0025	139	2.15	.30	.09
92	2.1	.25	.0625	140	1.9	.05	.0025
93	1.75	.1	.01	141	1.95	.1	.01
94	1.9	.05	.0025	142	2.-	.15	.0225
95	1.6	.25	.0625	143	1.8	.05	.0025
96	1.65	.2	.04	144	1.95	.1	.01
97	1.95	.1	.01	145	2.1	.25	.0625
98	2.-	.15	.0225	146	1.9	.05	.0025
99	1.8	.05	.0025	147	2.-	.15	.0225
100	1.95	.1	.01	148	1.75	.1	.01
101	1.95	.1	.01	149	2.05	.2	.04
102	1.9	.05	.0025	150	1.8	.05	.0025
103	1.95	.1	.01	151	1.9	.05	.0025
104	1.95	.1	.01	152	1.9	.05	.0025
105	1.55	.30	.09	153	2.1	.25	.0625
106	1.6	.25	.0625	154	2.15	.30	.09
107	1.55	.30	.09	155	1.8	.05	.0025
108	1.7	.15	.0225	156	1.7	.15	.0225
109	1.8	.05	.0025	157	1.8	.05	.0025
110	1.85	.0	-	158	1.5	.35	.1225

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<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>	<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>
159	1.75	.1	.01	208	1.85	.0	-
160	1.75	.1	.01	209	2.05	.2	.04
161	2.1	.25	.0625	210	1.85	.0	-
162	1.75	.1	.01	211	1.9	.05	.0025
163	1.65	.2	.04	212	1.85	.0	-
164	1.7	.15	.0225	213	1.9	.05	.0025
165	1.75	.1	.01	214	2.-	.15	.0225
166	1.85	.0	-	215	2.05	.2	.04
167	1.75	.1	.01	216	1.95	.1	.01
168	1.6	.25	.0625	217	1.9	.05	.0025
169	1.7	.15	.0225	218	2.1	.25	.0625
170	1.65	.2	.04	219	1.85	.0	-
171	1.75	.1	.01	220	2.05	.2	.04
172	1.75	.1	.01	221	1.95	.1	.01
173	1.9	.05	.0025	222	1.9	.05	.0025
174	1.7	.15	.0225	223	1.85	.0	-
175	1.9	.05	.0025	224	1.95	.1	.01
176	1.8	.05	.0025	225	1.85	.0	-
177	2.-	.15	.0225	226	2.1	.25	.0625
178	2.1	.25	.0625	227	2.-	.15	.0225
179	2.1	.25	.0625	228	1.95	.1	.01
180	1.85	.0	-	229	1.9	.05	.0025
181	1.75	.1	.01	230	1.75	.1	.01
182	1.7	.15	.0225	231	1.95	.1	.01
183	1.75	.1	.01	232	1.85	.0	-
184	2.05	.2	.04	233	2.15	.30	.09
185	1.95	.1	.01	234	2.05	.2	.04
186	1.75	.1	.01	235	1.85	.0	-
187	1.9	.05	.0025	236	2.1	.25	.0625
188	1.55	.30	.09	237	2.1	.25	.0625
189	2.1	.25	.0625	238	1.85	.0	-
190	1.65	.2	.04	239	2.-	.15	.0225
191	1.7	.15	.0225	240	1.9	.05	.0025
192	1.65	.2	.04	241	1.65	.2	.04
193	1.6	.25	.0625	242	1.85	.0	-
194	1.95	.1	.01	243	1.9	.05	.0025
195	2.1	.25	.0625	244	1.65	.2	.04
196	1.65	.2	.04	245	1.75	.1	.01
197	1.7	.15	.0225	246	1.7	.15	.0225
198	2.-	.15	.0225	247	1.75	.1	.01
199	1.85	.0	-	248	1.8	.05	.0025
200	1.75	.1	.01	249	1.95	.10	.01
201	2.-	.15	.0225	250	1.7	.15	.0225
202	2.05	.2	.04	251	1.9	.05	.0025
203	1.7	.15	.0225	252	1.65	.2	.04
204	1.65	.2	.04	253	1.85	.0	-
205	1.7	.15	.0225	254	1.95	.1	.01
206	1.75	.1	.01	255	1.8	.05	.0025
207	1.8	.05	.0025	256	1.65	.2	.04

<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>	<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>
257	1.85	.0	-	307	1.8	.05	.0025
258	1.8	.05	.0025	308	1.9	.05	.0025
259	1.6	.25	.0625	309	1.75	.1	.01
260	1.8	.05	.0025	310	2.-	.15	.0225
261	1.85	.0	-	311	1.9	.05	.0025
262	2.-	.15	.0225	312	1.8	.05	.0025
263	1.9	.05	.0025	313	2.-	.15	.0225
264	1.85	.0	-	314	1.85	.0	-
265	1.8	.05	.0025	315	1.8	.05	.0025
266	1.95	.1	.01	316	1.85	.0	-
267	1.9	.05	.0025	317	1.8	.05	.0025
268	1.85	.0	-	318	1.9	.05	.0025
269	1.8	.05	.0025	319	1.95	.1	.01
270	1.95	.1	.01	320	2.-	.15	.0225
271	2.-	.15	.0225	321	1.95	.1	.01
272	1.7	.15	.0225	322	1.9	.05	.0025
273	1.95	.1	.01	323	1.85	.0	-
274	1.85	.0	-	324	2.-	.15	.0225
275	1.75	.1	.01	325	1.95	.1	.01
276	1.8	.05	.0025	326	1.85	.0	-
277	2.-	.15	.0225	327	1.9	.05	.0025
278	1.9	.05	.0025	328	1.95	.1	.01
279	1.9	.05	.0025	329	1.85	.0	-
280	2.-	.15	.0225	330	1.8	.05	.0025
281	1.95	.1	.01	331	1.85	.0	-
282	2.05	.2	.04	332	1.8	.05	.0025
283	1.95	.1	.01	333	1.9	.05	.0025
284	1.9	.05	.0025	334	2.-	.15	.0225
285	1.95	.1	.01	335	1.8	.05	.0025
286	2.-	.15	.0225	336	1.9	.05	.0025
287	1.9	.05	.0025	337	2.-	.15	.0225
288	2.15	.30	.09	338	1.95	.1	.01
289	1.95	.1	.01	339	1.85	.0	-
290	1.4	.45	.2025	340	2.-	.15	.0225
291	2.2	.45	.2025	341	1.85	.0	-
292	2.15	.30	.09	342	1.8	.05	.0025
293	1.95	.1	.01	343	2.-	.15	.0225
294	2.15	.30	.09	344	2.1	.25	.0625
295	1.95	.1	.01	345	2.-	.15	.0225
296	1.8	.05	.0025	346	1.9	.05	.0025
297	1.75	.1	.01	347	1.95	.1	.01
298	1.8	.05	.0025	348	1.85	.0	-
299	1.85	.0	-	349	2.-	.15	.0225
300	1.75	.1	.01	350	1.9	.05	.0025
301	1.8	.05	.0025	351	2.1	.25	.0625
302	1.85	.0	-	352	1.85	.0	-
303	1.9	.05	.0025	353	1.95	.1	.01
304	1.85	.0	-	354	1.8	.05	.0025
305	1.8	.05	.0025	355	1.85	.0	-
306	1.75	.1	.01	356	1.75	.1	.01

No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
357	1.7	.15	.0225	407	1.4	.45	.2025
358	2.1	.25	.0625	408	1.9	.05	.0025
359	1.85	.0	-	409	1.8	.05	.0025
360	1.95	.1	.01	410	1.75	.1	.01
361	1.85	.0	-	411	1.95	.1	.01
362	1.8	.05	.0025	412	1.6	.25	.0625
363	2.1	.25	.0625	413	1.55	.30	.09
364	1.8	.05	.0025	414	1.8	.05	.0025
365	1.9	.05	.0025	415	1.85	.0	-
366	2.-	.15	.0225	416	1.75	.1	.01
367	1.8	.05	.0025	417	1.5	.35	.1225
368	1.95	.1	.01	418	2.05	.2	.04
369	1.8	.05	.0025	419	1.5	.35	.1225
370	1.85	.0	-	420	1.85	.0	-
371	1.95	.1	.01	421	1.95	.1	.01
372	2.1	.25	.0625	422	2.05	.2	.04
373	1.85	.0	-	423	1.75	.1	.01
374	2.-	.15	.0225	424	1.95	.1	.01
375	2.25	.40	.16	425	2.2	.35	.1225
376	2.-	.15	.0225	426	1.8	.05	.0025
377	2.1	.25	.0625	427	2.-	.15	.0225
378	1.9	.05	.0025	428	1.85	.0	-
379	1.85	.0	-	429	2.1	.25	.0625
380	2.25	.40	.16	430	2.1	.25	.0625
381	2.-	.15	.0225	431	1.9	.05	.0025
382	1.95	.1	.01	432	1.65	.2	.04
383	2.1	.15	.0225	433	1.95	.1	.01
384	1.95	.1	.01	434	1.85	.0	-
385	1.9	.05	.0025	435	2.05	.2	.04
386	2.-	.15	.0225	436	2.5	.65	.4225
387	1.85	.0	-	437	2.15	.30	.09
388	1.95	.1	.01	438	1.75	.1	.01
389	1.85	.0	-	439	1.8	.05	.0025
390	1.75	.1	.01	440	2.15	.30	.09
391	1.65	.2	.04	441	1.9	.05	.0025
392	1.5	.35	.1225	442	2.0	.15	.0225
393	1.9	.05	.0025	443	1.6	.25	.0625
394	1.9	.05	.0025	444	1.9	.05	.0025
395	1.6	.25	.0625	445	2.15	.30	.09
396	1.65	.20	.04	446	1.9	.05	.0025
397	1.7	.15	.0225	447	1.8	.05	.0025
398	1.5	.35	.1225	448	1.9	.05	.0025
399	1.5	.35	.1225	449	2.05	.2	.04
400	1.55	.30	.09	450	1.95	.10	.01
401	1.75	.1	.01	451	1.9	.05	.0025
402	1.95	.1	.01	452	1.85	.0	-
403	1.75	.1	.01	453	2.15	.30	.09
404	1.8	.05	.0025	454	1.85	.0	-
405	1.45	.40	.16	455	2.-	.15	.0225
406	1.4	.45	.2025	456	2.10	.25	.0625

No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
457	2.-	.15	.0225	507	1.65	.20	.04
458	1.85	.0	-	508	1.7	.15	.0225
459	2.1	.25	.0625	509	1.65	.20	.04
460	1.8	.05	.0025	510	1.55	.30	.09
461	2.1	.25	.0625	511	1.75	.1	.01
462	2.15	.30	.09	512	1.85	.0	-
463	2.1	.25	.0625	513	1.55	.30	.09
464	2.15	.3	.09	514	1.85	.0	-
465	2.05	.2	.04	515	1.55	.30	.09
466	2.2	.35	.1225	516	1.8	.05	.0025
467	2.05	.2	.04	517	1.5	.35	.1225
468	1.8	.05	.0025	518	1.85	.0	-
469	1.8	.05	.0025	519	1.9	.05	.0025
470	1.75	.1	.01	520	1.65	.20	.04
471	2.05	.2	.04	521	1.7	.15	.0225
472	1.6	.25	.0625	522	1.8	.05	.0025
473	1.75	.1	.01	523	1.7	.15	.0225
474	1.65	.20	.04	524	1.75	.1	.01
475	1.6	.25	.0625	525	1.85	.0	-
476	1.65	.2	.04	526	1.95	.1	.01
477	1.75	.1	.01	527	1.8	.05	.0025
478	1.7	.15	.0225	528	1.85	.0	-
479	1.9	.05	.0025	529	1.75	.1	.01
480	1.85	.0	-	530	1.7	.15	.0225
481	2.15	.30	.09	531	2.2	.35	.1225
482	1.8	.05	.0025	532	2.15	.30	.09
483	1.6	.25	.0625	533	1.9	.05	.0025
484	1.6	.25	.0625	534	1.95	.1	.01
485	1.65	.20	.04	535	2.-	.15	.0225
486	1.75	.1	.01	536	1.85	.0	-
487	1.60	.25	.0625	537	1.6	.25	.0625
488	1.75	.1	.01	538	1.75	.1	.01
489	1.8	.05	.0025	539	1.7	.15	.0225
490	1.7	.15	.0225	540	1.85	.0	-
491	1.7	.15	.0225	541	1.8	.05	.0025
492	1.75	.1	.01	542	1.75	.1	.01
493	1.85	.0	-	543	1.7	.15	.0225
494	1.75	.1	.01	544	1.85	.0	-
495	1.8	.05	.0025	545	1.8	.05	.0025
496	1.65	.20	.04	546	1.75	.1	.01
497	2.-	.15	.0225	547	1.7	.15	.0225
498	1.65	.20	.04	548	1.8	.05	.0025
499	1.65	.20	.04	549	1.9	.05	.0025
500	1.65	.20	.04	550	1.95	.1	.01
501	1.7	.15	.0225	551	1.7	.15	.0225
502	1.8	.05	.0025	552	1.65	.20	.04
503	2.1	.25	.0625	553	1.75	.1	.01
504	2.-	.15	.0225	554	1.7	.15	.0225
505	1.8	.05	.0025	555	1.5	.35	.1225
506	1.85	.0	-	556	1.65	.20	.04

No.	(x)	(x - \bar{x})	(x - \bar{x}) ²	No.	(x)	(x - \bar{x})	(x - \bar{x}) ²
557	1.85	.0	-	607	1.95	.1	.01
558	1.65	.20	.04	608	1.9	.05	.0025
559	1.75	.1	.01	609	2.-	.15	.0225
560	1.8	.05	.0025	610	1.95	.1	.01
561	1.85	.0	-	611	2.-	.15	.0225
562	1.9	.05	.0025	612	1.85	.0	-
563	1.85	.0	-	613	1.95	.1	.01
564	1.75	.1	.01	614	1.9	.05	.0025
565	1.65	.20	.04	615	2.-	.15	.0225
566	1.6	.25	.0625	616	1.95	.1	.01
567	1.9	.05	.0025	617	1.85	.0	-
568	1.75	.1	.01	618	1.9	.05	.0025
569	1.85	.0	-	619	1.95	.1	.01
570	1.7	.15	.0225	620	1.9	.05	.0025
571	1.75	.1	.01	621	1.95	.1	.01
572	1.7	.15	.0225	622	1.75	.1	.01
573	1.95	.1	.01	623	1.8	.05	.0025
574	1.8	.05	.0025	624	1.7	.15	.0225
575	1.85	.0	-	625	1.75	.1	.01
576	1.9	.05	.0025	626	1.8	.05	.0025
577	1.65	.20	.0225	627	1.65	.20	.04
578	1.9	.05	.0025	628	2.2	.35	.1225
579	1.8	.05	.0025	629	1.8	.05	.0025
580	1.75	.1	.01	630	1.75	.1	.01
581	1.85	.0	-	631	1.7	.15	.0225
582	1.75	.1	.01	632	1.85	.0	-
583	1.9	.05	.0025	633	1.7	.15	.0225
584	2.-	.15	.0225	634	1.8	.05	.0025
585	1.8	.05	.0025	635	1.9	.05	.0025
586	1.9	.05	.0025	636	1.85	.0	-
587	1.8	.05	.0025	637	1.8	.05	.0025
588	1.95	.1	.01	638	1.7	.15	.0225
589	1.75	.1	.01	639	1.75	.1	.01
590	1.95	.1	.01	640	1.85	.0	-
591	1.9	.05	.0025	641	1.8	.05	.0025
592	1.95	.1	.01	642	1.9	.05	.0025
593	2.10	.25	.0625	643	1.85	.0	-
594	1.8	.05	.0025	644	1.8	.05	.0025
595	1.95	.1	.01	645	1.85	.0	-
596	1.85	.0	-	646	1.9	.05	.0025
597	1.8	.05	.0025	647	1.85	.0	-
598	1.95	.1	.01	648	1.75	.1	.01
599	1.85	.0	-	649	1.9	.05	.0025
600	1.95	.1	.01	650	2.2	.35	.1225
601	1.95	.1	.01	651	1.95	.1	.01
602	1.9	.05	.0025	652	2.15	.30	.09
603	1.85	.0	-	653	1.95	.1	.01
604	1.95	.1	.01	654	1.9	.05	.0025
605	2.1	.25	.0625	655	2.-	.15	.0225
606	2.-	.15	.0225	656	1.9	.05	.0025

No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
657	2.-	.15	.0225	707	1.7	.15	.0225
658	1.9	.05	.0025	708	1.8	.05	.0025
659	2.-	.15	.0225	709	1.9	.05	.0025
660	1.95	.1	.01	710	2.1	.25	.0625
661	1.9	.05	.0025	711	1.9	.05	.0025
662	1.95	.1	.01	712	1.9	.05	.0025
663	1.8	.05	.0025	713	2.1	.25	.0625
664	1.9	.05	.0025	714	1.9	.05	.0025
665	1.95	.1	.01	715	1.85	.0	-
666	1.9	.05	.0025	716	1.8	.05	.0025
667	1.85	.0	-	717	2.15	.30	.09
668	1.95	.1	.01	718	2.1	.25	.0625
669	1.9	.05	.0025	719	2.-	.15	.0225
670	1.65	.20	.04	720	1.85	.0	-
671	1.9	.05	.0025	721	1.85	.0	-
672	1.65	.20	.04	722	2.1	.25	.0625
673	1.85	.0	-	723	2.-	.15	.0225
674	1.95	.1	.01	724	2.2	.35	.1225
675	1.7	.15	.0225	725	1.8	.05	.0025
676	2.15	.30	.09	726	1.75	.1	.01
677	1.9	.05	.0025	727	1.8	.05	.0025
678	1.75	.1	.01	728	1.85	.0	-
679	1.6	.25	.0625	729	1.8	.05	.0025
680	1.6	.25	.0625	730	1.8	.05	.0025
681	1.75	.1	.01	731	1.85	.0	-
682	1.90	.05	.0025	732	1.75	.1	.01
683	2.-	.15	.0225	733	1.85	.0	-
684	1.8	.05	.0025	734	1.8	.05	.0025
685	1.8	.05	.0025	735	2.2	.35	.1225
686	1.85	.0	-	736	1.7	.15	.0225
687	1.75	.1	.01	737	1.75	.1	.01
688	1.65	.20	.04	738	1.75	.1	.01
689	1.65	.20	.04	739	1.85	.0	-
690	1.85	.0	-	740	1.8	.05	.0025
691	1.8	.05	.0025	741	1.8	.05	.0025
692	1.75	.1	.01	742	1.6	.25	.0625
693	1.75	.1	.01	743	1.85	.0	-
694	1.8	.05	.0025	744	1.3	.55	.3025
695	1.85	.0	-	745	1.6	.25	.0625
696	1.85	.0	-	746	1.6	.25	.0625
697	1.8	.05	.0025	747	1.6	.25	.0625
698	1.6	.25	.0625	748	1.75	.1	.01
699	1.9	.05	.0025	749	1.85	.0	-
700	2.15	.30	.09	750	1.75	.1	.01
701	1.9	.05	.0025	751	1.6	.25	.0625
702	1.8	.05	.0025	752	1.8	.05	.0025
703	2.15	.30	.09	753	1.6	.25	.0625
704	2.20	.35	.1225	754	1.75	.1	.01
705	2.10	.25	.0625	755	1.6	.25	.0625
706	2.-	.15	.0225	756	1.85	.0	-

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No.	(x)	(x - \bar{x})	(x - \bar{x}) ²	No.	(x)	(x - \bar{x})	(x - \bar{x}) ²
757	1.75	.1	.01	807	1.65	.2	.04
758	1.65	.20	.04	808	2.1	.25	.0625
759	2.25	.40	.16	809	1.65	.2	.04
760	1.85	.0	-	810	2.25	.40	.16
761	1.8	.05	.0025	811	1.75	.1	.01
762	1.85	.0	-	812	1.8	.05	.0025
763	1.8	.05	.0025	813	1.9	.05	.0025
764	1.9	.05	.0025	814	1.5	.35	.1225
765	1.75	.1	.01	815	1.65	.2	.04
766	1.95	.1	.01	816	1.85	.0	-
767	1.8	.05	.0025	817	1.95	.1	.01
768	2.-	.15	.0225	818	1.8	.05	.0025
769	2.1	.25	.0625	819	1.75	.1	.01
770	1.95	.1	.01	820	1.95	.1	.01
771	1.9	.05	.0025	821	1.9	.05	.0025
772	1.8	.05	.0025	822	2.-	.15	.0225
773	1.9	.05	.0025	823	1.95	.1	.01
774	1.85	.0	-	824	2.05	.20	.04
775	2.1	.25	.0625	825	1.95	.1	.01
776	1.9	.05	.0025	826	2.1	.25	.0625
777	1.85	.0	-	827	2.-	.15	.0225
778	1.65	.20	.04	828	1.9	.05	.0025
779	1.9	.05	.0025	829	2.2	.35	.1225
780	1.95	.1	.01	830	1.95	.1	.01
781	2.-	.15	.0225	831	2.1	.25	.0625
782	1.85	.0	-	832	2.-	.15	.0225
783	1.95	.1	.01	833	2.2	.35	.1225
784	2.1	.25	.0625	834	2.25	.40	.16
785	2.-	.15	.0225	835	1.95	.1	.01
786	1.9	.05	.0025	836	1.85	.0	-
787	1.95	.1	.01	837	1.9	.05	.0025
788	1.85	.0	-	838	2.-	.15	.0225
789	1.8	.03	.0025	839	1.85	.0	-
790	1.75	.1	.01	840	1.8	.05	.0025
791	1.65	.20	.04	841	1.9	.05	.0025
792	1.85	.0	-	842	1.95	.1	.01
793	1.8	.05	.0025	843	1.85	.0	-
794	1.9	.05	.0025	844	2.-	.15	.0225
795	1.85	.0	-	845	1.8	.05	.0025
796	1.9	.05	.0025	846	1.9	.05	.0025
797	1.95	.1	.01	847	1.95	.1	.01
798	1.9	.05	.0025	848	1.6	.25	.0625
799	1.75	.1	.01	849	1.5	.35	.1225
800	1.65	.20	.04	850	1.65	.20	.04
801	2.-	.15	.0225	851	1.95	.1	.01
802	1.75	.1	.01	852	2.15	.30	.09
803	1.65	.20	.04	853	1.85	.0	-
804	2.25	.40	.16	854	1.75	.1	.01
805	1.85	.0	-	855	2.1	.25	.0625
806	1.75	.1	.01	856	1.65	.1	.01

No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
857	2.25	.40	.16	907	1.85	.0	-
858	2.-	.15	.0225	908	2.0	.15	.0225
859	1.65	.1	.01	909	1.95	.1	.01
860	1.75	.1	.01	910	1.65	.20	.04
861	1.65	.1	.01	911	1.85	.0	-
862	1.75	.1	.01	912	1.75	.1	.01
863	1.65	.1	.01	913	1.7	.15	.0225
864	1.8	.05	.0025	914	1.85	.0	-
865	1.9	.05	.0025	915	1.8	.05	.0025
866	1.75	.1	.01	916	2.-	.15	.0225
867	1.8	.05	.0025	917	1.9	.05	.0025
868	1.85	.0	-	918	1.85	.0	-
869	2.-	.15	.0225	919	2.1	.25	.0625
870	1.75	.1	.01	920	1.85	.0	-
871	1.7	.15	.0225	921	1.8	.05	.0025
872	1.75	.1	.01	922	1.95	.1	.01
873	1.65	.2	.04	923	1.75	.1	.01
874	1.75	.1	.01	924	1.8	.05	.0025
875	1.7	.15	.0225	925	1.9	.05	.0025
876	1.65	.2	.04	926	1.95	.1	.01
877	1.75	.1	.01	927	1.75	.1	.01
878	2.-	.15	.0225	928	1.95	.1	.01
879	1.8	.05	.0025	929	1.65	.2	.04
880	1.9	.05	.0025	930	1.6	.25	.0625
881	1.8	.05	.0025	931	1.85	.05	.0025
882	1.75	.1	.01	932	1.9	.05	.0025
883	2.1	.25	.0625	933	1.85	.0	-
884	1.9	.05	.0025	934	1.9	.05	.0025
885	1.95	.1	.01	935	1.7	.15	.0225
886	2.05	.20	.04	936	1.9	.05	.0025
887	2.25	.40	.16	937	1.8	.05	.0025
888	1.85	.0	-	938	1.9	.05	.0025
889	1.9	.05	.0025	939	2.15	.30	.09
890	1.85	.0	-	940	1.95	.1	.01
891	1.95	.1	.01	941	1.85	.0	-
892	2.20	.35	.1225	942	1.75	.1	.01
893	2.10	.25	.0625	943	1.65	.2	.04
894	2.25	.40	.16	944	1.75	.1	.01
895	1.85	.0	-	945	1.7	.15	.0225
896	1.95	.1	.01	946	2.25	.40	.16
897	2.2	.35	.1225	947	1.9	.05	.0025
898	1.95	.1	.01	948	1.8	.05	.0025
899	2.-	.15	.0225	949	1.85	.0	-
900	2.1	.25	.0625	950	1.75	.1	.01
901	1.8	.05	.0025	951	1.95	.1	.01
902	1.9	.05	.0025	952	2.-	.15	.0225
903	2.05	.20	.04	953	1.85	.0	-
904	1.9	.05	.0025	954	1.8	.05	.0025
905	1.95	.1	.01	955	2.15	.30	.09
906	1.9	.05	.0025	956	1.9	.05	.0025

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No.	(x)	(x - \bar{x})	(x - \bar{x}) ²	No.	(x)	(x - \bar{x})	(x - \bar{x}) ²
957	1.95	.1	.01	1007	1.9	.05	.0025
958	1.6	.25	.0625	1008	1.85	.0	-
959	1.9	.05	.0025	1009	1.9	.05	.0025
960	1.75	.1	.01	1010	2.-	.15	.0225
961	2.0	.15	.0225	1011	1.75	.1	.01
962	1.85	.0	-	1012	1.9	.05	.0025
963	1.9	.05	.0025	1013	1.8	.05	.0025
964	1.95	.1	.01	1014	1.9	.05	.0025
965	1.9	.05	.0025	1015	1.95	.1	.01
966	1.85	.0	-	1016	1.9	.05	.0025
967	1.8	.05	.0025	1017	1.8	.05	.0025
968	1.9	.05	.0025	1018	2.2	.35	.1225
969	1.65	.2	.04	1019	2.05	.20	.04
970	1.75	.1	.01	1020	1.9	.05	.0025
971	1.6	.25	.0625	1021	2.-	.15	.0225
972	1.85	.0	-	1022	2.1	.25	.0625
973	1.8	.05	.0025	1023	1.85	.0	-
974	1.85	.0	-	1024	1.75	.1	.01
975	1.8	.05	.0025	1025	1.95	.1	.01
976	1.7	.15	.0225	1026	1.85	.0	-
977	1.8	.05	.0025	1027	1.75	.1	.01
978	1.65	.20	.04	1028	1.85	.0	-
979	1.6	.25	.0625	1029	1.7	.15	.0225
980	1.8	.05	.0025	1030	1.6	.25	.0625
981	1.65	.2	.04	1031	2.2	.35	.1225
982	1.95	.1	.01	1032	1.7	.15	.0225
983	1.8	.05	.0025	1033	1.8	.05	.0025
984	1.85	.0	-	1034	1.9	.05	.0025
985	1.95	.1	.01	1035	1.75	.1	.01
986	2.1	.25	.0625	1036	1.7	.15	.0225
987	1.65	.2	.04	1037	1.9	.05	.0025
988	1.7	.15	.0225	1038	2.1	.25	.0625
989	1.9	.05	.0025	1039	1.85	.0	-
990	1.85	.0	-	1040	1.75	.1	.01
991	1.9	.05	.0025	1041	1.8	.05	.0025
992	1.8	.05	.0025	1042	1.75	.1	.01
993	1.85	.0	-	1043	1.9	.05	.0025
994	2.-	.15	.0225	1044	1.85	.0	-
995	1.75	.1	.01	1045	1.6	.25	.0625
996	1.8	.05	.0025	1046	1.95	.1	.01
997	1.75	.1	.01	1047	1.8	.05	.0025
998	1.85	.0	-	1048	1.75	.1	.01
999	1.6	.25	.0625	1049	2.15	.30	.09
1000	1.7	.15	.0225	1050	1.75	.1	.01
1001	1.95	.1	.01	1051	1.7	.15	.0225
1002	1.7	.15	.0225	1052	1.85	.0	-
1003	1.95	.1	.01	1053	1.7	.15	.0225
1004	1.75	.1	.01	1054	1.8	.05	.0025
1005	1.85	.0	-	1055	1.95	.1	.01
1006	1.8	.05	.0025	1056	2.-	.15	.0225

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No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
1057	1.85	.0	-	1107	1.95	.1	.01
1058	1.75	.1	.01	1108	1.75	.1	.01
1059	1.85	.0	-	1109	1.95	.1	.01
1060	1.95	.1	.01	1110	1.8	.05	.0025
1061	2.05	.20	.04	1111	1.9	.05	.0025
1062	1.85	.0	-	1112	1.8	.05	.0025
1063	1.8	.05	.0025	1113	2.1	.25	.0625
1064	1.9	.05	.0025	1114	1.75	.1	.01
1065	1.8	.05	.0025	1115	1.8	.25	.0625
1066	1.9	.05	.0025	1116	1.9	.25	.0625
1067	1.85	.0	-	1117	1.6	.25	.0625
1068	1.8	.05	.0025	1118	1.8	.05	.0025
1069	1.9	.05	.0025	1119	2.-	.15	.0225
1070	1.85	.0	-	1120	1.85	.0	-
1071	1.9	.05	.0025	1121	1.95	.1	.01
1072	2.-	.15	.0225	1122	1.8	.05	.0025
1073	1.85	.0	-	1123	1.6	.25	.0625
1074	1.9	.05	.0025	1124	1.8	.05	.0025
1075	2.-	.15	.0225	1125	1.6	.25	.0625
1076	2.1	.25	.0625	1126	1.85	.0	-
1077	1.95	.1	.01	1127	1.9	.05	.0025
1078	2.05	.20	.04	1128	1.75	.1	.01
1079	1.9	.05	.0025	1129	2.-	.15	.0225
1080	1.85	.0	-	1130	1.95	.1	.01
1081	1.95	.1	.01	1131	2.05	.20	.04
1082	1.85	.0	-	1132	1.9	.05	.0025
1083	1.8	.05	.0025	1133	1.8	.05	.0025
1084	1.95	.1	.01	1134	1.95	.1	.01
1085	1.9	.05	.0025	1135	1.8	.05	.0025
1086	1.6	.25	.0625	1136	1.95	.1	.01
1087	2.1	.25	.0625	1137	1.8	.05	.0025
1088	1.75	.1	.01	1138	1.95	.1	.01
1089	1.8	.05	.0025	1139	1.85	.0	-
1090	1.85	.0	-	1140	1.8	.05	.0025
1091	1.9	.05	.0025	1141	1.95	.1	.01
1092	1.7	.15	.0225	1142	1.8	.05	.0025
1093	1.85	.0	-	1143	1.65	.1	.01
1094	1.90	.05	.0025	1144	1.65	.1	.01
1095	1.85	.0	-	1145	1.6	.25	.0625
1096	2.-	.15	.0225	1146	1.8	.05	.0025
1097	1.75	.1	.01	1147	1.85	.0	-
1098	1.95	.1	.01	1148	2.25	.40	.16
1099	1.75	.1	.01	1149	1.95	.1	.01
1100	2.-	.15	.0225	1150	1.6	.25	.0625
1101	1.65	.1	.01	1151	2.-	.15	.0225
1102	2.05	.20	.04	1152	1.8	.05	.0025
1103	2.-	.15	.0225	1153	1.85	.0	-
1104	2.25	.40	.16	1154	1.8	.05	.0025
1105	2.-	.15	.0225	1155	1.75	.1	.01
1106	1.8	.05	.0025	1156	1.7	.15	.0225

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No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
1157	1.7	.15	.0225	1207	1.9	.05	.0025
1158	1.8	.05	.0025	1208	1.8	.05	.0025
1159	1.75	.1	.01	1209	2.-	.15	.0225
1160	1.75	.1	.01	1210	1.8	.05	.0025
1161	1.7	.15	.0225	1211	1.8	.05	.0025
1162	1.6	.25	.0625	1212	1.75	.1	.01
1163	1.55	.30	.09	1213	1.95	.1	.01
1164	1.85	.0	-	1214	1.85	.0	-
1165	1.95	.1	.01	1215	1.8	.05	.0025
1166	1.7	.15	.0225	1216	1.85	.1	.01
1167	1.95	.1	.01	1217	2.25	.40	.16
1168	1.8	.05	.0025	1218	1.9	.05	.0025
1169	1.7	.15	.0225	1219	1.8	.05	.0025
1170	1.7	.15	.0225	1220	1.95	.1	.01
1171	1.75	.1	.01	1221	1.7	.15	.0225
1172	1.7	.15	.0225	1222	1.75	.1	.01
1173	1.8	.05	.0025	1223	2.10	.25	.0625
1174	1.85	.0	-	1224	1.75	.1	.01
1175	1.9	.05	.0025	1225	1.8	.05	.0025
1176	1.8	.05	.0025	1226	2.1	.25	.0625
1177	1.8	.05	.0025	1227	2.2	.35	.1225
1178	1.95	.1	.01	1228	1.8	.05	.0025
1179	2.-	.15	.0225	1229	1.8	.05	.0025
1180	1.75	.1	.01	1230	2.05	.20	.04
1181	2.-	.15	.0225	1231	2.1	.25	.0625
1182	1.9	.05	.0025	1232	1.95	.1	.01
1183	1.85	.0	-	1233	2.-	.15	.0225
1184	1.8	.05	.0025	1234	1.75	.1	.01
1185	1.95	.1	.01	1235	1.8	.05	.0025
1186	2.05	.20	.04	1236	1.75	.1	.01
1187	1.85	.0	-	1237	1.5	.35	.1225
1188	2.15	.30	.09	1238	1.55	.30	.09
1189	2.-	.15	.0225	1239	1.65	.20	.04
1190	2.15	.30	.09	1240	1.65	.20	.04
1191	2.-	.15	.0225	1241	2.15	.30	.09
1192	1.8	.05	.0025	1242	2.15	.30	.09
1193	1.95	.1	.01	1243	1.6	.25	.0625
1194	1.8	.05	.0025	1244	1.7	.15	.0225
1195	1.95	.1	.01	1245	1.6	.25	.0575
1196	2.05	.20	.04	1246	1.7	.15	.0225
1197	1.8	.05	.0025	1247	1.7	.15	.0225
1198	1.8	.05	.0025	1248	1.7	.15	.0225
1199	2.-	.15	.0225	1249	1.6	2.5	.0625
1200	1.85	.0	-	1250	1.8	.05	.0025
1201	2.15	.30	.09	1251	1.8	.05	.0025
1202	1.9	.05	.0025	1252	1.8	.05	.0025
1203	1.8	.05	.0025	1253	1.75	.1	.01
1204	1.85	.0	-	1254	1.7	.15	.0225
1205	1.85	.0	-	1255	1.7	.15	.0225
1206	1.75	.1	.01	1256	1.75	.1	.01

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No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
1257	1.8	.05	.0025	1307	1.95	.1	.01
1258	1.8	.05	.0025	1308	1.6	.25	.0625
1259	1.8	.05	.0025	1309	1.85	.0	-
1260	1.85	.0	-	1310	1.8	.05	.0025
1261	1.75	.1	.01	1311	1.95	.1	.01
1262	1.85	.0	-	1312	1.8	.05	.0025
1263	1.75	.1	.01	1313	1.65	.20	.04
1264	1.85	.0	-	1314	1.7	.15	.0225
1265	1.65	.20	.04	1315	1.6	.25	.0625
1266	1.8	.05	.0025	1316	1.95	.1	.01
1267	1.85	.0	-	1317	1.9	.05	.0025
1268	1.8	.05	.0025	1318	1.75	.1	.01
1269	1.75	.1	.01	1319	1.7	.15	.0225
1270	1.8	.05	.0025	1320	1.8	.05	.0025
1271	1.8	.05	.0025	1321	1.75	.1	.01
1272	1.95	.1	.01	1322	1.8	.05	.0025
1273	1.95	.1	.01	1323	1.75	.1	.01
1274	2.10	.25	.0625	1324	1.8	.05	.0025
1275	1.85	.0	-	1325	1.85	.0	-
1276	1.85	.0	-	1326	1.8	.05	.0025
1277	2.05	.20	.04	1327	1.95	.1	.01
1278	1.95	.1	.01	1328	1.6	.25	.0625
1279	1.9	.05	.0025	1329	1.7	.15	.0225
1280	1.95	.1	.01	1330	1.7	.15	.0225
1281	2.05	.20	.04	1331	1.75	.1	.01
1282	1.9	.05	.0025	1332	1.55	.30	.09
1283	1.8	.05	.0025	1333	1.75	.1	.01
1284	2.05	.20	.04	1334	1.75	.1	.01
1285	1.9	.05	.0025	1335	1.8	.05	.0025
1286	1.95	.1	.01	1336	1.75	.1	.01
1287	1.85	.0	-	1337	1.8	.05	.0025
1288	1.8	.05	.0025	1338	1.85	.0	-
1289	1.75	.1	.01	1339	1.8	.05	.0025
1290	1.8	.05	.0025	1340	1.85	.0	-
1291	2.05	.20	.04	1341	2.-	.15	.0225
1292	1.95	.1	.01	1342	2.05	.20	.04
1293	2.-	.15	.0225	1343	2.2	.35	.1225
1294	2.-	.15	.0225	1344	1.9	.05	.0025
1295	1.95	.1	.01	1345	2.-	.15	.0225
1296	1.8	.05	.0025	1346	1.9	.05	.0025
1297	1.55	.30	.09	1347	2.05	.20	.04
1298	1.6	.25	.0625	1348	1.95	.1	.01
1299	1.7	.15	.0225	1349	1.85	.0	-
1300	1.75	.1	.01	1350	2.05	.20	.04
1301	1.6	.25	.0625	1351	2.05	.20	.04
1302	1.75	.1	.01	1352	2.15	.30	.09
1303	1.8	.05	.0025	1353	2.-	.15	.0225
1304	1.85	.0	-	1354	1.95	.1	.01
1305	1.8	.05	.0025	1355	1.55	.30	.09
1306	1.55	.30	.09	1356	2.1	.25	.0625

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No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
1357	2.1	.25	.0625	1407	2.05	.20	.04
1358	1.6	.25	.0625	1408	2.-	.15	.0225
1359	1.7	.15	.0225	1409	1.95	.1	.01
1360	1.65	.20	.04	1410	2.05	.20	.04
1361	2.05	.20	.04	1411	2.05	.20	.04
1362	1.7	.15	.0225	1412	1.95	.1	.01
1363	1.65	.20	.04	1413	1.95	.1	.01
1364	1.6	.25	.0625	1414	1.8	.05	.0025
1365	1.7	.15	.0225	1415	1.95	.1	.01
1366	1.85	.0	-	1416	1.9	.1	.01
1367	1.75	.1	.01	1417	2.05	.20	.04
1368	1.7	.15	.0225	1418	1.8	.05	.0025
1369	1.75	.1	.01	1419	2.-	.15	.0225
1370	1.55	.30	.09	1420	2.05	.20	.04
1371	1.8	.05	.0025	1421	2.-	.15	.0225
1372	1.55	.30	.09	1422	2.1	.25	.0625
1373	1.75	.1	.01	1423	2.1	.25	.0625
1374	1.7	.15	.0225	1424	1.95	.1	.01
1375	1.8	.05	.0025	1425	2.-	.15	.0225
1376	1.8	.05	.0025	1426	2.-	.15	.0225
1377	1.85	.0	-	1427	1.95	.1	.01
1378	1.8	.05	.0025	1428	2.1	.25	.0625
1379	1.95	.1	.01	1429	2.05	.20	.04
1380	1.85	.0	-	1430	2.05	.20	.04
1381	2.05	.20	.04	1431	2.-	.15	.0225
1382	1.9	.05	.0025	1432	1.85	.0	-
1383	1.85	.0	-	1433	2.2	.35	.1225
1384	1.65	.20	.04	1434	1.9	.1	.01
1385	2.05	.20	.04	1435	2.2	.35	.1225
1386	1.9	.05	.0025	1436	1.95	.1	.01
1387	1.8	.05	.0025	1437	1.8	.05	.0025
1388	1.85	.0	-	1438	1.8	.05	.0025
1389	1.9	.05	.0025	1439	2.-	.15	.0225
1390	1.95	.1	.01	1440	1.9	.05	.0025
1391	1.9	.05	.0025	1441	1.85	.0	-
1392	1.85	.0	-	1442	1.95	.1	.01
1393	1.8	.05	.0025	1443	1.95	.1	.01
1394	2.-	.15	.0225	1444	2.-	.15	.0225
1395	1.8	.05	.0025	1445	1.9	.05	.0025
1396	2.05	.20	.04	1446	1.75	.1	.01
1397	1.9	.05	.0025	1447	1.75	.1	.01
1398	1.9	.05	.0025	1448	2.-	.15	.0225
1399	1.95	.1	.01	1449	2.05	.20	.04
1400	2.05	.20	.04	1450	1.85	.0	-
1401	2.2	.35	.1225	1451	1.65	.20	.04
1402	2.-	.15	.0225	1452	1.75	.1	.01
1403	1.95	.1	.01	1453	1.85	.0	-
1404	1.95	.1	.01	1454	1.75	.1	.01
1405	1.95	.1	.01	1455	1.8	.05	.0025
1406	2.-	.15	.0225	1456	1.85	.0	-

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No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
1457	1.85	.0	-	1507	1.85	.0	-
1458	1.8	.05	.0025	1508	1.7	.15	.0225
1459	1.65	.20	.04	1509	1.85	.0	-
1460	1.65	.20	.04	1510	1.8	.05	.0025
1461	1.8	.05	.0025	1511	1.75	.1	.01
1462	1.9	.05	.0025	1512	1.75	.1	.01
1463	2.2	.35	.1225	1513	1.9	.05	.0025
1464	1.85	.0	-	1514	1.8	.05	.0025
1465	1.8	.05	.0025	1515	1.6	.25	.0625
1466	1.85	.0	-	1516	2.-	.15	.0225
1467	1.85	.0	-	1517	1.75	.1	.01
1468	1.8	.05	.0025	1518	2.-	.15	.0225
1469	1.85	.0	-	1519	2.1	.25	.0625
1470	1.85	.0	-	1520	2.05	.20	.04
1471	1.7	.15	.0225	1521	1.9	.05	.0025
1472	2.0	.15	.0225	1522	1.8	.05	.0025
1473	1.85	.0	-	1523	1.75	.1	.01
1474	2.-	.15	.0225	1524	2.-	.15	.0225
1475	1.8	.05	.0025	1525	1.95	.1	.01
1476	2.05	.20	.04	1526	1.75	.1	.01
1477	1.75	.1	.01	1527	1.9	.05	.0025
1478	1.8	.05	.0025	1528	2.05	.20	.04
1479	1.75	.1	.01	1529	2.2	.35	.1225
1480	2.-	.15	.0225	1530	1.8	.05	.0025
1481	1.8	.05	.0025	1531	1.75	.1	.01
1482	1.9	.05	.0025	1532	2.15	.30	.09
1483	1.8	.05	.0025	1533	1.9	.05	.0025
1484	2.15	.30	.09	1534	1.95	.1	.01
1485	1.95	.1	.01	1535	2.05	.20	.04
1486	2.25	.40	.16	1536	1.75	.1	.01
1487	1.75	.1	.01	1537	1.9	.05	.0025
1488	2.-	.15	.0225	1538	2.-	.15	.0225
1489	1.8	.05	.0025	1539	2.0	.15	.0225
1490	1.85	.0	-	1540	1.8	.05	.0025
1491	1.95	.1	.01	1541	2.05	.20	.04
1492	1.85	.0	-	1542	2.-	.15	.0225
1493	1.8	.05	.0025	1543	1.75	.1	.01
1494	1.6	.25	.0625	1544	2.1	.25	.0625
1495	1.85	.0	-	1545	2.1	.25	.0625
1496	1.95	.1	.01	1546	1.8	.05	.0025
1497	1.75	.1	.01	1547	2.-	.15	.0225
1498	1.8	.05	.0025	1548	1.95	.1	.01
1499	1.85	.0	-	1549	1.8	.05	.0025
1500	1.85	.0	-	1550	2.05	.20	.04
1501	1.85	.0	-	1551	1.75	.1	.01
1502	1.75	.1	.01	1552	1.8	.05	.0025
1503	1.85	.0	-	1553	2.15	.30	.09
1504	1.75	.1	.01	1554	1.8	.05	.0025
1505	2.05	.20	.04	1555	1.95	.1	.01
1506	1.75	.1	.01	1556	2.25	.40	.16

No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
1557	1.95	.1	.01	1607	1.8	.05	.0025
1558	1.85	.0	-	1608	1.9	.05	.0025
1559	1.9	.05	.0025	1609	1.85	.0	-
1560	2.05	.20	.04	1610	1.95	.1	.01
1561	1.95	.1	.01	1611	1.9	.05	.0025
1562	1.85	.0	-	1612	1.95	.1	.01
1563	1.75	.1	.01	1613	1.85	.0	-
1564	1.8	.05	.0025	1614	1.95	.1	.01
1565	1.75	.1	.01	1615	2.05	.20	.04
1566	1.75	.1	.01	1616	1.95	.1	.01
1567	1.85	.0	-	1617	1.9	.05	.0025
1568	1.9	.05	.0025	1618	2.05	.20	.04
1569	1.9	.05	.0025	1619	1.8	.05	.0025
1570	1.8	.05	.0025	1620	1.85	.0	-
1571	1.85	.0	-	1621	1.85	.0	-
1572	1.7	.15	.0225	1622	1.8	.05	.0025
1573	1.75	.1	.01	1623	1.75	.1	.01
1574	1.95	.1	.01	1624	1.85	.0	-
1575	1.95	.1	.01	1625	1.8	.05	.0025
1576	1.9	.05	.0025	1626	1.85	.0	-
1577	1.9	.05	.0025	1627	1.9	.05	.0025
1578	1.85	.0	-	1628	1.8	.05	.0025
1579	1.8	.05	.0025	1629	1.9	.05	.0025
1580	1.85	.0	-	1630	1.75	.1	.01
1581	1.85	.0	-	1631	1.8	.05	.0025
1582	1.75	.1	.01	1632	1.85	.0	-
1583	1.85	.0	-	1633	2.05	.20	.04
1584	1.85	.0	-	1634	1.8	.05	.0025
1585	1.95	.1	.01	1635	1.95	.1	.01
1586	1.95	.1	.01	1636	2.05	.20	.04
1587	1.95	.1	.01	1637	1.85	.0	-
1588	1.8	.05	.0025	1638	1.9	.05	.0025
1589	2.-	.15	.0225	1639	2.05	.20	.04
1590	1.95	.1	.01	1640	1.95	.1	.01
1591	2.-	.15	.0225	1641	2.1	.25	.0625
1592	1.8	.05	.0025	1642	1.75	.1	.01
1593	1.9	.05	.0025	1643	1.8	.05	.0025
1594	1.95	.1	.01	1644	1.85	.0	-
1595	1.85	.0	-	1645	1.95	.1	.01
1596	1.8	.05	.0025	1646	1.85	.0	-
1597	2.15	.30	.09	1647	1.85	.0	-
1598	1.75	.1	.01	1648	1.85	.0	-
1599	1.85	.0	-	1649	1.75	.1	.01
1600	1.8	.05	.0025	1650	1.85	.0	-
1601	1.9	.05	.0025	1651	1.85	.0	-
1602	1.9	.05	.0025	1652	1.9	.05	.0025
1603	1.8	.05	.0025	1653	1.95	.1	.01
1604	1.8	.05	.0025	1654	1.7	.15	.0225
1605	1.85	.0	-	1655	1.9	.05	.0025
1606	1.75	.1	.01	1656	1.75	.1	.01

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No.	(x)	(x - \bar{x})	(x - \bar{x}) ²	No.	(x)	(x - \bar{x})	(x - \bar{x}) ²
1657	1.9	.05	.0025	1707	1.85	.0	-
1658	1.75	.1	.01	1708	1.95	.1	.01
1659	1.85	.0	-	1709	1.9	.05	.0025
1660	1.95	.1	.01	1710	2.-	.15	.0225
1661	1.8	.05	.0025	1711	1.9	.05	.0025
1662	1.8	.05	.0025	1712	1.75	.1	.01
1663	1.85	.0	-	1713	2.-	.15	.0225
1664	1.9	.05	.0025	1714	1.75	.1	.01
1665	1.95	.1	.01	1715	1.75	.1	.01
1666	2.-	.15	.0225	1716	1.7	.15	.0225
1667	1.8	.05	.0025	1717	2.1	.25	.0625
1668	1.9	.05	.0025	1718	1.9	.05	.0025
1669	1.85	.0	-	1719	1.75	.1	.01
1670	1.8	.05	.0025	1720	1.85	.0	-
1671	1.8	.05	.0025	1721	1.95	.1	.01
1672	1.8	.05	.0025	1722	1.8	.05	.0025
1673	2.15	.30	.09	1723	1.75	.1	.01
1674	1.85	.0	-	1724	1.65	.2	.04
1675	1.85	.0	-	1725	1.85	.0	-
1676	1.75	.1	.01	1726	1.8	.05	.0025
1677	1.8	.05	.0025	1727	1.6	.25	.0625
1678	2.1	.25	.0625	1728	2.05	.20	.04
1679	2.-	.15	.0225	1729	1.85	.0	-
1680	1.9	.05	.0025	1730	1.85	.0	-
1681	1.85	.0	-	1731	1.9	.05	.0025
1682	1.85	.0	-	1732	1.75	.1	.01
1683	1.95	.1	.01	1733	1.9	.05	.0025
1684	1.8	.05	.0025	1734	1.7	.15	.0225
1685	1.85	.0	-	1735	1.85	.0	-
1686	1.8	.05	.0025	1736	1.85	.0	-
1687	1.95	.1	.01	1737	2.05	.20	.04
1688	1.95	.1	.01	1738	1.85	.0	-
1689	1.8	.05	.0025	1739	1.75	.1	.01
1690	1.85	.0	-	1740	1.8	.05	.0025
1691	1.9	.05	.0025	1741	1.75	.1	.01
1692	1.6	.25	.0625	1742	2.-	.15	.0225
1693	1.9	.05	.0025	1743	1.75	.1	.01
1694	1.25	.60	.36	1744	1.7	.15	.0225
1695	2.2	.35	.1225	1745	1.75	.1	.01
1696	1.85	.0	-	1746	1.95	.1	.01
1697	1.7	.15	.0225	1747	1.8	.05	.0025
1698	1.9	.05	.0025	1748	1.95	.1	.01
1699	1.85	.0	-	1749	1.85	.0	-
1700	1.85	.0	-	1750	1.75	.1	.01
1701	1.7	.15	.0225	1751	1.85	.0	-
1702	1.85	.0	-	1752	1.85	.0	-
1703	1.9	.05	.0025	1753	1.85	.0	-
1704	1.8	.05	.0025	1754	1.75	.1	.01
1705	1.85	.0	-	1755	2.1	.25	.0625
1706	1.9	.05	.0025	1756	2.-	.15	.0225

No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
1757	1.75	.1	.01	1807	1.8	.05	.0025
1758	1.95	.1	.01	1808	1.75	.1	.01
1759	1.95	.1	.01	1809	1.75	.1	.01
1760	1.8	.05	.0025	1810	1.8	.05	.0025
1761	2.15	.30	.09	1811	2.05	.20	.04
1762	1.95	.1	.01	1812	1.9	.05	.0025
1763	1.9	.05	.0025	1813	1.85	.0	-
1764	1.95	.1	.01	1814	2.15	.30	.09
1765	1.75	.1	.01	1815	1.9	.02	.04
1766	1.85	.0	-	1816	1.9	.02	.04
1767	1.8	.05	.0025	1817	2.-	.15	.0225
1768	2.-	.15	.0225	1818	1.8	.05	.0025
1769	2.05	.20	.04	1819	1.95	.1	.01
1770	2.15	.30	.09	1820	1.9	.05	.0025
1771	1.8	.05	.0025	1821	1.95	.1	.01
1772	1.95	.1	.01	1822	2.05	.20	.04
1773	1.8	.05	.0025	1823	1.95	.1	.01
1774	1.8	.05	.0025	1824	2.1	.25	.0625
1775	1.95	.1	.01	1825	2.-	.15	.0225
1776	1.8	.05	.0025	1826	1.8	.05	.0025
1777	1.75	.1	.01	1827	1.8	.05	.0025
1778	1.9	.05	.0025	1828	2.-	.15	.0225
1779	2.-	.15	.0225	1829	1.9	.05	.0025
1780	1.9	.05	.0025	1830	2.1	.25	.0625
1781	2.05	.20	.04	1831	1.6	.25	.0625
1782	1.85	.0	-	1832	1.8	.05	.0025
1783	2.-	.15	.0225	1833	2.05	.20	.04
1784	1.8	.05	.0025	1834	1.85	.0	-
1785	1.9	.05	.0025	1835	1.85	.0	-
1786	2.1	.25	.0625	1836	1.95	.1	.01
1787	2.-	.15	.0225	1837	1.8	.05	.0025
1788	1.95	.1	.01	1838	2.05	.20	.04
1789	2.05	.20	.04	1839	1.95	.1	.01
1790	1.65	.2	.04	1840	2.05	.20	.04
1791	1.75	.1	.01	1841	1.8	.05	.0025
1792	1.8	.05	.0025	1842	1.8	.05	.0025
1793	2.05	.20	.04	1843	1.85	.0	-
1794	1.75	.1	.01	1844	1.85	.0	-
1795	1.85	.0	-	1845	1.8	.05	.0025
1796	1.8	.05	.0025	1846	2.05	.20	.04
1797	1.95	.1	.01	1847	1.95	.1	.01
1798	1.85	.0	-	1848	2.-	.15	.0225
1799	1.9	.05	.0025	1849	1.75	.1	.01
1800	1.7	.15	.0225	1850	1.85	.0	-
1801	1.85	.0	-	1851	1.8	.05	.0025
1802	1.8	.05	.0025	1852	2.-	.15	.0225
1803	1.65	.2	.04	1853	1.8	.05	.0025
1804	1.75	.1	.01	1854	1.8	.05	.0025
1805	1.6	.25	.0625	1855	1.8	.05	.0025
1806	1.7	.15	.0225	1856	1.95	.1	.01

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No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
1857	1.85	.0	-	1907	2.15	.30	.09
1858	1.8	.05	.0025	1908	1.95	.1	.01
1859	1.95	.1	.01	1909	1.85	.0	-
1860	1.95	.1	.01	1910	1.7	.15	.0225
1861	1.9	.05	.0025	1911	1.95	.1	.01
1862	1.8	.05	.0025	1912	1.85	.0	-
1863	1.75	.1	.01	1913	2.-	.15	.0225
1864	1.6	.25	.0625	1914	1.9	.05	.0025
1865	1.65	.20	.04	1915	2.1	.25	.0625
1866	1.85	.0	-	1916	1.95	.1	.01
1867	1.95	.1	.01	1917	1.95	.1	.01
1868	1.7	.15	.0225	1918	2.-	.15	.0225
1869	1.75	.1	.01	1919	2.-	.15	.0225
1870	1.55	.30	.09	1920	1.8	.05	.0025
1871	2.05	.20	.04	1921	1.9	.05	.0025
1872	2.-	.15	.0225	1922	2.1	.25	.0625
1873	1.95	.1	.01	1923	1.8	.05	.0025
1874	1.75	.1	.01	1924	1.85	.0	-
1875	2.1	.25	.0625	1925	1.95	.1	.01
1876	2.05	.20	.04	1926	1.7	.15	.0225
1877	2.05	.20	.04	1927	1.85	.0	-
1878	1.85	.0	-	1928	1.8	.05	.0025
1879	2.-	.15	.0225	1929	1.95	.1	.01
1880	1.8	.05	.0025	1930	1.85	.0	-
1881	1.85	.0	-	1931	1.95	.1	.01
1882	1.95	.1	.01	1932	2.-	.15	.0225
1883	1.85	.0	-	1933	1.85	.0	-
1884	1.8	.05	.0025	1934	1.9	.05	.0025
1885	2.-	.15	.0225	1935	1.9	.05	.0025
1886	1.75	.1	.01	1936	1.85	.0	-
1887	1.85	.0	-	1937	1.85	.0	-
1888	1.65	.2	.04	1938	1.95	.1	.01
1889	1.9	.05	.0025	1939	1.85	.0	-
1890	1.8	.05	.0025	1940	1.8	.05	.0025
1891	1.95	.1	.01	1941	1.75	.1	.01
1892	1.80	.05	.0025	1942	1.8	.05	.0025
1893	1.80	.05	.0025	1943	1.8	.05	.0025
1894	1.85	.0	-	1944	2.-	.15	.0225
1895	1.75	.1	.01	1945	1.85	.0	-
1896	1.65	.2	.04	1946	2.-	.15	.0225
1897	1.85	.0	-	1947	1.95	.1	.01
1898	1.10	.75	.5625	1948	1.95	.1	.01
1899	2.10	.25	.0625	1949	1.85	.0	-
1900	1.85	.0	-	1950	1.9	.05	.0025
1901	1.85	.0	-	1951	1.95	.1	.01
1902	2.-	.15	.0225	1952	1.95	.1	.01
1903	1.80	.05	.0025	1953	1.85	.0	-
1904	2.-	.15	.0225	1954	1.85	.0	-
1905	1.95	.1	.01	1955	1.8	.05	.0025
1906	2.05	.20	.04	1956	1.95	.1	.01

<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>	<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>
1957	1.95	.1	.01	2007	1.8	.05	.0025
1958	1.85	.0	-	2008	1.85	.0	-
1959	1.85	.0	-	2009	1.9	.05	.0025
1960	1.65	.2	.04	2010	1.95	.1	.01
1961	2.15	.30	.09	2011	1.8	.05	.0025
1962	1.95	.1	.01	2012	1.95	.1	.01
1963	2.05	.20	.04	2013	2.05	.20	.04
1964	1.7	.15	.0225	2014	1.8	.05	.0025
1965	2.1	.25	.0625	2015	1.7	.15	.0225
1966	2.05	.20	.04	2016	1.95	.1	.01
1967	1.8	.05	.0025	2017	1.95	.1	.01
1968	1.8	.05	.0025	2018	1.95	.1	.01
1969	1.85	.0	-	2019	1.9	.05	.0025
1970	1.95	.1	.01	2020	1.85	.0	-
1971	1.95	.1	.01	2021	1.95	.1	.01
1972	1.95	.1	.01	2022	1.85	.0	-
1973	1.85	.0	-	2023	1.95	.1	.01
1974	1.9	.05	.0025	2024	2.-	.15	.0225
1975	1.8	.05	.0025	2025	1.8	.05	.0025
1976	1.85	.0	-	2026	1.95	.1	.01
1977	2.05	.20	.04	2027	1.9	.05	.0025
1978	1.95	.1	.01	2028	2.05	.20	.04
1979	1.9	.05	.0025	2029	1.95	.1	.01
1980	1.85	.0	-	2030	2.05	.20	.04
1981	1.85	.0	-	2031	1.8	.05	.0025
1982	1.8	.05	.0025	2032	1.95	.1	.01
1983	1.95	.1	.01	2033	1.2	.65	.4225
1984	2.05	.20	.04	2034	2.1	.25	.0625
1985	1.95	.1	.01	2035	1.65	.2	.04
1986	1.9	.05	.0025	2036	1.8	.05	.0025
1987	2.-	.15	.0225	2037	1.75	.1	.01
1988	1.7	.15	.0225	2038	1.95	.1	.01
1989	1.95	.1	.01	2039	1.95	.1	.01
1990	1.7	.15	.0225	2040	1.95	.1	.01
1991	1.8	.05	.0025	2041	1.75	.1	.01
1992	2.05	.20	.04	2042	1.95	.1	.01
1993	2.-	.15	.0225	2043	1.85	.0	-
1994	1.7	.15	.0225	2044	1.8	.05	.0025
1995	2.-	.15	.0225	2045	1.95	.1	.01
1996	1.7	.15	.0225	2046	1.85	.0	-
1997	1.65	.2	.04	2047	1.8	.05	.0025
1998	1.85	.0	-	2048	1.95	.1	.01
1999	1.7	.15	.0225	2049	1.9	.05	.0025
2000	1.8	.05	.0025	2050	2.05	.20	.04
2001	2.05	.20	.04	2051	1.8	.05	.0025
2002	2.05	.20	.04	2052	2.-	.15	.0225
2003	1.8	.05	.0025	2053	2.1	.25	.0625
2004	1.85	.0	-	2054	1.9	.05	.0025
2005	1.7	.15	.0225	2055	2.05	.20	.04
2006	1.75	.1	.01	2056	1.95	.1	.01

No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
2057	1.85	.0	-	2107	2.15	.30	.09
2058	1.95	.1	.01	2108	1.8	.05	.0025
2059	1.9	.05	.0025	2109	2.05	.20	.04
2060	1.75	.1	.01	2110	2.1	.25	.0625
2061	1.8	.05	.0025	2111	1.95	.1	.01
2062	1.85	.0	-	2112	1.9	.05	.0025
2063	1.9	.05	.0025	2113	1.95	.1	.01
2064	1.75	.1	.01	2114	1.95	.1	.01
2065	1.95	.1	.01	2115	2.-	.15	.0225
2066	1.85	.0	-	2116	2.15	.30	.09
2067	2.2	.35	.1225	2117	1.85	.0	-
2068	1.8	.05	.0025	2118	2.15	.30	.09
2069	1.9	.05	.0025	2119	2.2	.35	.1225
2070	2.1	.25	.0625	2120	2.2	.35	.1225
2071	1.95	.1	.01	2121	1.9	.05	.0025
2072	1.85	.0	-	2122	1.8	.05	.0025
2073	1.85	.0	-	2123	1.95	.1	.01
2074	1.75	.1	.01	2124	1.8	.05	.0025
2075	1.85	.0	-	2125	2.-	.15	.0225
2076	1.8	.05	.0025	2126	1.95	.1	.01
2077	1.95	.1	.01	2127	1.95	.1	.01
2078	2.1	.25	.0625	2128	1.85	.0	-
2079	2.-	.15	.0225	2129	2.15	.30	.09
2080	1.8	.05	.0025	2130	1.95	.1	.01
2081	1.8	.05	.0025	2131	1.95	.1	.01
2082	2.05	.20	.04	2132	1.95	.1	.01
2083	1.85	.0	-	2133	1.85	.0	-
2084	1.95	.1	.01	2134	1.75	.1	.01
2085	1.95	.1	.01	2135	1.75	.1	.01
2086	1.85	.0	-	2136	2.-	.15	.0225
2087	1.9	.05	.0025	2137	1.85	.0	-
2088	1.85	.0	-	2138	1.9	.05	.0025
2089	1.95	.1	.01	2139	2.05	.20	.04
2090	1.9	.05	.0025	2140	1.85	.0	-
2091	1.85	.0	-	2141	1.8	.05	.0025
2092	1.9	.05	.0025	2142	2.-	.15	.0225
2093	1.85	.0	-	2143	1.95	.1	.01
2094	2-	.15	.0225	2144	1.9	.05	.0025
2095	1.95	.1	.01	2145	1.8	.05	.0025
2096	2.15	.30	.09	2146	1.85	.0	-
2097	1.9	.05	.0025	2147	2.-	.15	.0225
2098	2.-	.15	.0225	2148	1.95	.1	.01
2099	1.9	.05	.0025	2149	1.8	.05	.0025
2100	2.05	.20	.04	2150	2.25	.40	.16
2101	2.-	.15	.0225	2151	1.85	.0	-
2102	1.85	.0	-	2152	1.65	.2	.04
2103	1.95	.1	.01	2153	1.95	.1	.01
2104	1.85	.0	-	2154	1.95	.1	.01
2105	1.85	.0	-	2155	1.85	.0	-
2106	2.05	.20	.04	2156	1.85	.0	-

<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>	<u>No.</u>	<u>(x)</u>	<u>(x - \bar{x})</u>	<u>(x - \bar{x})²</u>
2157	1.9	.05	.0025	2207	2.-	.15	.0225
2158	1.85	.0	-	2208	1.95	.1	.01
2159	1.85	.0	-	2209	1.95	.1	.01
2160	1.8	.05	.0025	2210	1.85	.0	-
2161	1.9	.05	.0025	2211	1.95	.1	.01
2162	1.8	.05	.0025	2212	1.8	.05	.0025
2163	1.7	.15	.0225	2213	2.05	.20	.04
2164	1.8	.05	.0025	2214	1.85	.0	-
2165	1.85	.0	-	2215	2.-	.15	.0225
2166	1.85	.0	-	2216	1.95	.1	.01
2167	2.05	.20	.04	2217	1.8	.05	.0025
2168	1.8	.05	.0025	2218	2.05	.20	.04
2169	1.8	.05	.0025	2219	1.9	.05	.0025
2170	1.9	.05	.0025	2220	1.85	.0	-
2171	1.85	.0	-	2221	1.8	.05	.0025
2172	1.95	.1	.01	2222	2.-	.15	.0225
2173	2.1	.25	.0625	2223	1.85	.0	-
2174	1.9	.05	.0025	2224	2.05	.20	.04
2175	1.95	.1	.01	2225	1.8	.05	.0025
2176	1.95	.1	.01	2226	1.85	.0	-
2177	2.05	.20	.04	2227	2.05	.20	.04
2178	2.-	.15	.0225	2228	2.2	.35	.1225
2179	2.15	.30	.09	2229	2.05	.20	.04
2180	1.85	.0	-	2230	1.8	.05	.0025
2181	2.-	.15	.0225	2231	1.85	.0	-
2182	2.1	.25	.0625	2232	2.05	.20	.04
2183	1.85	.0	-	2233	1.8	.05	.0025
2184	1.95	.1	.01	2234	1.85	.0	-
2185	1.85	.0	-	2235	2.2	.35	.1225
2186	1.8	.05	.0025	2236	1.9	.05	.0025
2187	2.05	.20	.04	2237	2.25	.40	.16
2188	1.95	.1	.01	2238	2.1	.25	.0625
2189	1.85	.0	-	2239	2.-	.15	.0225
2190	2.1	.25	.0625	2240	2.05	.20	.04
2191	1.9	.05	.0025	2241	1.85	.0	-
2192	2.1	.25	.0625	2242	2.2	.35	.1225
2193	2.0	.15	.0225	2243	2.25	.40	.16
2194	2.0	.15	.0225	2244	2.05	.30	.04
2195	1.8	.05	.0025	2245	2.-	.15	.0225
2196	1.85	.0	-	2246	2.1	.25	.0625
2197	1.75	.1	.01	2247	1.85	.0	-
2198	2.-	.15	.0225	2248	2.15	.30	.09
2199	2.2	.35	.1225	2249	2.2	.35	.1225
2200	1.9	.05	.0025	2250	1.85	.0	-
2201	1.9	.05	.0025	2251	1.85	.0	-
2202	2.05	.20	.04	2252	1.9	.05	.0025
2203	1.95	.1	.01	2253	1.85	.0	-
2204	1.8	.05	.0025	2254	2.05	.20	.04
2205	2.2	.35	.1225	2255	2.15	.30	.09
2206	1.95	.1	.01	2256	1.95	.1	.01

No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$	No.	(x)	$(x - \bar{x})$	$(x - \bar{x})^2$
2257	1.8	.05	.0025	2307	2.-	.15	.0225
2258	1.75	.1	.01	2308	2.1	.25	.0625
2259	1.85	.0	-	2309	1.8	.05	.0025
2260	1.7	.15	.0225	2310	2.-	.15	.0225
2261	2.-	.15	.0225	2311	1.85	.0	-
2262	1.75	.1	.01	2312	2.2	.35	.1225
2263	1.95	.1	.01	2313	2.2	.35	.1225
2264	2.2	.35	.1225	2314	1.95	.1	.01
2265	1.9	.05	.0025	2315	1.9	.05	.0025
2266	1.7	.15	.0225	2316	1.85	.0	-
2267	2.1	.25	.0625	2317	1.8	.05	.0025
2268	1.75	.1	.01	2318	1.95	.1	.01
2269	1.85	.0	-	2319	1.9	.05	.0025
2270	2.05	.20	.04	2320	1.8	.05	.0025
2271	1.8	.05	.0025	2321	1.95	.1	.01
2272	1.8	.05	.0025	2322	2.-	.15	.0225
2273	1.65	.2	.04	2323	1.8	.05	.0025
2274	1.85	.0	-	2324	1.9	.05	.0025
2275	1.75	.1	.01	2325	1.95	.1	.01
2276	1.8	.05	.0025	2326	1.9	.05	.0025
2277	1.9	.05	.0025	2327	1.8	.05	.0025
2278	1.75	.1	.01	2328	1.95	.1	.01
2279	1.8	.05	.0025	2329	1.95	.1	.01
2280	1.9	.05	.0025	2330	1.85	.0	-
2281	1.7	.15	.0225	2331	1.75	.1	.01
2282	1.8	.05	.0025	2332	1.75	.1	.01
2283	1.85	.0	-	2333	1.8	.05	.0025
2284	1.8	.05	.0025	2334	1.85	.0	-
2285	1.85	.0	-	2335	1.7	.15	.0225
2286	1.8	.05	.0025	2336	1.7	.15	.0225
2287	1.7	.15	.0225	2337	1.85	.0	-
2288	1.8	.05	.0025	2338	1.8	.05	.0025
2289	2.-	.15	.0225	2339	1.7	.15	.0225
2290	2.05	.20	.04	2340	1.95	.1	.01
2291	1.85	.0	-	2341	1.85	.0	-
2292	1.8	.05	.0025	2342	1.85	.0	-
2293	2.05	.20	.04	2343	2.1	.25	.0625
2294	2.2	.35	.1225	2344	1.9	.05	.0025
2295	2.15	.30	.09	2345	2.2	.35	.1225
2296	1.95	.1	.01	2346	1.73	.05	.0025
2297	2.-	.15	.0225	2347	1.85	.0	-
2298	2.15	.30	.09	2348	1.9	.05	.0025
2299	1.95	.1	.01	2349	2.2	.35	.1225
2300	1.8	.05	.0025	2350	1.95	.1	.01
2301	2.-	.15	.0225	2351	1.75	.1	.01
2302	2.2	.35	.1225	2352	1.75	.1	.01
2303	2.05	.20	.04	2353	1.85	.0	-
2304	2.1	.25	.0625	2354	2.15	.30	.09
2305	2.2	.35	.1225	2355	2.1	.25	.0625
2306	1.95	.1	.01	2356	2.1	.25	.0625

No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
2357	1.9	.05	.0025	2407	2.05	.20	.04
2358	1.85	.0	-	2408	1.8	.05	.0025
2359	1.85	.0	-	2409	1.8	.05	.0025
2360	1.8	.05	.0025	2410	1.85	.0	-
2361	1.85	.0	-	2411	1.7	.15	.0225
2362	1.9	.05	.0025	2412	1.85	.0	-
2363	1.75	.1	.01	2413	1.95	.1	.01
2364	2.-	.15	.0225	2414	1.9	.05	.0025
2365	1.95	.1	.01	2415	2.2	.35	.1225
2366	2.-	.15	.0225	2416	2.2	.35	.1225
2367	1.95	.1	.01	2417	2.05	.20	.04
2368	2.0	.15	.0225	2418	1.95	.1	.01
2369	1.75	.1	.01	2419	1.9	.05	.0025
2370	2.05	.20	.04	2420	1.75	.1	.01
2371	1.8	.05	.0025	2421	1.8	.05	.0025
2372	1.95	.1	.01	2422	1.85	.0	-
2373	2.-	.15	.0225	2423	1.8	.05	.0025
2374	1.9	.05	.0025	2424	2.-	.15	.0225
2375	1.8	.05	.0025	2425	2.05	.20	.04
2376	1.75	.1	.01	2426	1.8	.05	.0025
2377	1.7	.15	.0225	2427	2.-	.15	.0225
2378	1.8	.05	.0025	2428	2.15	.30	.09
2379	1.7	.15	.0225	2429	1.75	.1	.01
2380	1.85	.0	-	2430	1.85	.0	-
2381	1.85	.0	-	2431	1.9	.05	.0025
2382	1.9	.05	.0025	2432	1.85	.0	-
2383	2.-	.15	.0225	2433	2.-	.15	.0225
2384	1.85	.0	-	2434	1.75	.1	.01
2385	1.85	.0	-	2435	1.95	.1	.01
2386	1.85	.0	-	2436	1.9	.05	.0025
2387	1.9	.05	.0025	2437	1.8	.05	.0025
2388	1.9	.05	.0025	2438	2.-	.15	.0225
2389	1.8	.05	.0025	2439	1.75	.1	.01
2390	1.9	.05	.0025	2440	2.-	.15	.0225
2391	1.9	.05	.0025	2441	2.05	.20	.04
2392	1.85	.0	-	2442	1.7	.15	.0225
2393	1.95	.1	.01	2443	2.-	.15	.0225
2394	1.85	.0	-	2444	1.75	.1	.01
2395	1.85	.0	-	2445	1.9	.05	.0025
2396	1.85	.0	-	2446	1.8	.05	.0025
2397	1.95	.1	.01	2447	1.9	.05	.0025
2398	1.95	.1	.01	2448	1.7	.15	.0225
2399	1.8	.05	.0025	2449	1.75	.1	.01
2400	1.75	.1	.01	2450	2.-	.15	.0225
2401	1.95	.1	.01	2451	1.95	.1	.01
2402	2.05	.20	.04	2452	2.05	.20	.04
2403	2.-	.15	.0225	2453	2.15	.30	.09
2404	1.85	.0	-	2454	2.0	.15	.0225
2405	1.95	.1	.01	2455	2.05	.2	.04
2406	1.9	.05	.0025	2456	2.2	.35	.1225

No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$	No.	(x)	(x - \bar{x})	$(x - \bar{x})^2$
2457	2.05	.2	.04				
2458	1.95	.1	.01				
2459	2.05	.2	.04				
2460	1.75	.1	.01				
2461	1.7	.15	.0225				
2462	1.85	.0	-				
2463	1.8	.05	.0025				
2464	1.95	.1	.01				
2465	1.95	.1	.01				
2466	1.8	.05	.0025				
2467	1.85	.0	-				
2468	1.95	.1	.01				
2469	1.8	.05	.0025				
2470	1.8	.05	.0025				
2471	1.9	.05	.0025				
2472	1.75	.1	.01				
2473	1.7	.15	.0225				
2474	1.65	.2	.04				
2475	1.85	.0	-				
2476	1.95	.1	.01				
2477	1.9	.05	.0025				
2478	1.75	.1	.01				
2479	1.7	.15	.0225				
2480	1.8	.05	.0025				
2481	2.05	.2	.04				
2482	2.1	.15	.0225				
2483	1.9	.05	.0025				
2484	1.85	-	-				
2485	2.-	.15	.0225				
2486	1.85	-	-				
2487	1.9	.05	.0025				
2488	1.75	.1	.01				
2489	2.05	.2	.04				
2490	1.45	.4	.16				
2491	1.6	.25	.0625				
2492	1.9	.05	.0025				
2493	1.95	.1	.01				
2494	1.7	.15	.0225				
2495	1.8	.05	.0025				
2496	1.75	.1	.01				
2497	1.5	.35	.1225				
2498	1.75	.1	.01				
2499	1.95	.1	.01				
2500	1.85	-	-				

APPENDIX C

Weld Schedules

While making the material, equipment and electrode investigations the preliminary ground work for the weld schedule was accomplished. Included in the appendix of this report is the actual weld schedule with the supporting data.

SEARCH ANALYSIS

The Superior Corporation
Pewabic Lab No. 1

Sugden Mount Sis.

Fig 8

1-36

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Search Lab No.:

PULSE WIDTH SEARCH

Conditions Set:
 Pressure: 2 lbs.
 Electrodes: Tung Mov '025"
 Material: A0063 Ni
 Polarity: Mat A to the Mov

Fixed 040 M1

Tung. Electrodes

CAPACITOR RANGE	TRANSFORMER TAP	BANK VOLTAGE											
		6	5	4	3	2	1	6	5	4	3	2	1
240	6	same as tap #4											
	5	same as tap #4	40V	45V	50V								
	4	f.o.	f.o.	f.o.				40-50V	Insulation damaged				
	3	30V	35V	40V	45V	50V		40-50V	Insulation damaged - getting worse				
	2	f.o.	f.o.	f.o.	.2#	.05#			as voltage goes up				
	1	30V	35V	40V	45V	50V		50V	Insulation going-weld spread out				
120	6	same as tap #4	40V	45V	50V								
	5	f.o.	f.o.	f.o.				@50V	weld flattened insulation OK.				
	4	30V	35V	40V	45V	50V		45V	50V				
	3	f.o.	f.o.	f.o.	.25#	.5#				50V	Insulation damaged		
	2	30V	35V	40V	45V	50V		45V	50V		50V	Insulation damaged	
	1	f.o.	f.o.	f.o.	.25	.5		f.o.	f.o.		55V	Insulation damaged	
60	6	same as tap #4	40V	45V	50V			55V	60V		60V	Insulation damaged	
	5	f.o.	f.o.	f.o.	.25#	.5#		f.o.	f.o.		55V	Insulation damaged	
	4	30V	35V	40V	45V	50V		55V	60V		60V	Weld spread out Insulation fair	
	3	f.o.	f.o.	f.o.	.25	.5		f.o.	f.o.		75V	80V	
	2	30V	35V	40V	45V	50V		75V	80V		80V	Insulation damaged	
	1	f.o.	f.o.	f.o.	.25	.5		f.o.	f.o.		90V	95V	
30	6	same as tap #4	40V	45V	50V			90V	95V		95V	Insulation damaged	
	5	f.o.	f.o.	f.o.				f.o.	f.o.		95V	Insulation damaged (little)	
	4	65V	70V	75V				95V	100V		100V	Insulation damaged	
	3	f.o.	f.o.	f.o.				f.o.	f.o.		100V	100V	
	2	65V	70V	75V				f.o.	f.o.		100V	100V	
	1	f.o.	f.o.	f.o.				f.o.	f.o.		100V	100V	
6	6	same as tap #4	65V	70V	75V			100V	105V		105V	Insulation damaged	
	5	f.o.	f.o.	f.o.				f.o.	f.o.		105V	105V	
	4	65V	70V	75V				f.o.	f.o.		105V	105V	
	3	f.o.	f.o.	f.o.				f.o.	f.o.		105V	105V	
	2	65V	70V	75V				f.o.	f.o.		105V	105V	
	1	f.o.	f.o.	f.o.				f.o.	f.o.		105V	105V	
1	6	All fell off											
	5												
	4												
	3												
	2												
	1												

BANK VOLTAGE

F.O. fell off.

119V 1.5#

115V 1.75#

Fig 9

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SIPPICAN PREWELD EVALUATION

CLIENT JPL		Date 2/4/65 S/O 107201
Attribute	Material A	Material B
Manufacturer	Magnet Wire Inc.	Wilber Driver
Manufacturer Type	Magnet Wire	Headed Pin
Lot # or Identification		.080" Long .032 diam head
Overall dimensions	.0063 diam .34 awg	.020 diam wire
Core material	Nickel	142 Alloy
Cladding material	-----	-----
Coating material	Formvar	-----
Resistivity	9.5 $\mu\Omega/cm$	
Thermal conductivity		
Melting point	2645°F	2635°F
Hardness	Soft	Soft
Recommended ETCH	HNO ₃ -HF	HNO ₃ -HF
Electrical cond.	18%	3.2%
Alloy attributes		
Core eutectic	Desired bond is either a nickel to iron-nickel fusing weld or diffusion bond with complete insulation removal	
Core intermetallic		
Clad eutectic		
Clad intermetallic		
Quality Results		
1. Electrode class - Movable electrode 2% Thoriated Tungsten .025 diam.		
2. Electrode tip size + Stationary electrode M1 .040 diam.		
3. Head type Special		
4. Power source #310 - Vari-Pulse 240 W/S		
5. Expected force range (lbs) 1 - 3		
6. Expected energy range (V/watt sec.) 30 W/S Scale Lo Range 1-3 Taps		
7. Configuration Vertical		
8. Material A to		
(a) Polarity - Movable .020 diam sect. of pin		
(b) Electrode Tungsten		

Comments:

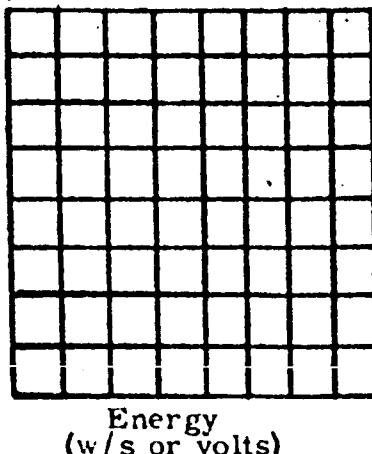
Fig 10

Lab. No. _____

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ENERGY/FORCE DIAGRAMS

Force
(lb.)Energy
(w/s or volts)

(1st Approximation)

30 W/S Range Low Scale

1 Tap

- Mov Mat A

(2nd Approximation)

Force
(lb.)

2.5

2.0

1.5

FO FO FO .25 .5 1.1 1.7 1.9 2.1 1.75 1.8 1.85

FO FO .25 .5 1.25 1.0 1.5 2.0 1.95 1.95 1.8 1.9

HO FO .25 .5 .5 .5 1.2 1.75 1.7 1.9 1.9 1.75 2.15

40V 45V 50V 55V 60V Energy 75V 80V 85V 90V 95V 100V

(w/s or volts)

(65) (70)

Fig II

A-37

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ANALYTICAL SAMPLE ANALYSIS

Analytical Sample No. _____

Pressure	2#	Watt/seconds	30 W/S
		volts	80 V

Search Analysis No. _____

Pre Weld Lab. No. _____

Search Analysis Lab. No. _____

1. Tensile Test (10 weldments)

Weld No.	1	2	3	4	5	6	7	8	9	10	Sum Σ
Pull (x) Test	2.0	1.9	1.95	1.75	2.15	1.85	1.95	2.15	2.0	2.3	20.0
\bar{x}	0	.1	.05	.25	.15	.15	.5	.15	0	.3	2.0
$(x - \bar{x})^2$	0	.01	.0025	.063	.023	.023	.01	.023	0	.09	.0945
Pull Test (y)	2.20	2.20	2.25	2.15	2.20	2.20	2.15	2.20	2.25	22.5	22.0

2. Visual Examination (3 weldments)

1. Uniform Spreading of Insulation
2. Slight Flattening of Ni
3. Slight Expulsion

$$\text{WQC} = \frac{\bar{x}}{\bar{y}} - 5\sigma$$

Fig. 12

3. Manual Examination (3 weldments)
 - Bend: Breaks in Nickel outside weld after 7 - 8 90° Bends.
 - Peel: Breaks in Nickel out of weld or Pull off with great difficulty.
 - Twist: Breaks in Nickel outside weld.

4. Metallographic examination (4 weldments)

- Cross section through weld. Nickel wire tightly imbedded in 142# pin. Bond is a partial diffusion bond with some local fusion. Excellent bond.

Lab. No. _____